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THE

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UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

UNITED STATES DEPARTMENT OF THE INTERIOR
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FISH AND WILDLIFE SERVICE
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THE PROGRESSIVE FISH-CULTURIST

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TABLE OF CONTENTS

Page

A New, Mechanically Adjustable Three-Way Grader
-- K. E. Morton 99

Effects of Transportation of Green Eggs, and of Water Temperature During Incubation, on the Mortality of Chinook Salmon
-- H. E. Johnson and R. F. Brice 104

Experiments With Nigrosine Dye in Aquatic Plant Control
-- N. O. Levardsen 109

Use of Pectoral Fin Rays To Determine Age of the White Sucker
-- W. J. Scidmore and A. W. Glass 114

A Report on the Fisheries of East Bengal, Pakistan
-- A. R. K. Zobairi 116

Methods and Techniques Used in Trap-Cropping Large-mouth Black Bass From Lake Mills, Wisconsin, Hatchery Ponds
-- N. J. Sears 121

Lake Mapping in Wisconsin
-- C. N. Lloyd 123

Should We Stock Brown Trout?
-- R. S. Nielson 125

Use of Pellets As Trout Food
-- Harvey Willoughby 127

Occurrence of High Mortality Among Chinook Salmon Fry After the Recharge of a Charcoal Filter
-- A. H. Seymour and J. R. Donaldson 129

The Rogue River Boat in Fishery Work
-- O. B. Cope 131

A Partial Bibliography on Reservoirs
-- W. C. Beckman and J. H. Kutkuhn 135

Dividends From Research

Pond Research in Alabama -- H. S. Swingle 133

Perch Studies in Green Bay -- Ralph Hile 133

Fisheries Research in Western Canada -- D. S. Rawson 134

Items

Damage by the Sea Lamprey 103
Helpful Hint for Carp Culturists! 108
Sodium Arsenite on Dry Pond Bottoms 113
Fresh-Water Fisheries of Mexico 120
Unobserved Mortalities 122
Factors in the "Red Tide" Outbreak of 1952 128
Changes in Length Measurements of Yellowstone Trout 132
Michigan Lake Maps for Fishermen 144

A NEW, MECHANICALLY ADJUSTABLE THREE-WAY GRADER

K. E. Morton
Wizard Falls Trout Hatchery
Camp Sherman, Oregon

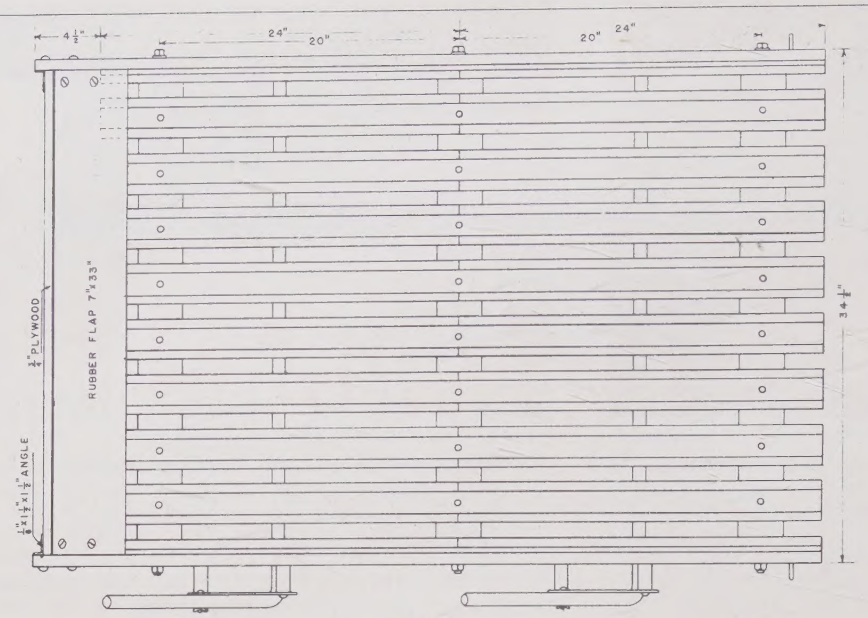
THE ACCOMPANYING DRAWING and photographs show in detail a new grader that the writer has been working on for several years. The grader has been perfected to a point where it will segregate any lot of fish into three distinct size groups in one grading. It probably would be feasible to enlarge upon the principle and have four size groups from one grading if such a segregation were desired.

It will be noted that the detailed drawing shows a different method of adjusting the grader from that shown in the photographs. The new method reduces the number of adjusting operations from 40 to 2, regulating the size of openings in the grader from 0 to 1 inch or to any minute setting between the two extremes. The writer regrets that time has not permitted the building of a full-scale working model of the grader with the new adjusting mechanism, but it worked so well in a small sectional model that the blueprint was changed to include the improvement. The basic operating principle of the grader is the same in either case.

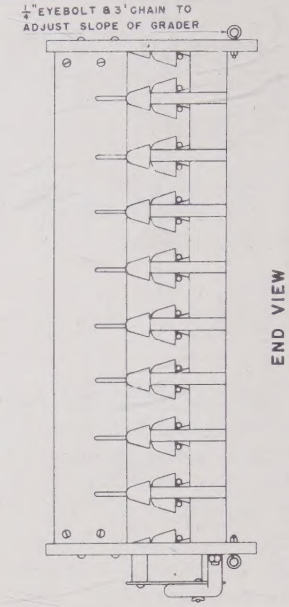
The idea for the apparatus was taken from an apple grader that the writer saw many years ago in the Hood River Valley. The grader was a simple affair in which the apples rolled down tapering grooves. The smaller apples dropped through first, into bins below; the larger the apple, the farther it would roll until the groove was large enough for the apple to drop through. Here, it seemed, was a principle that could be applied to fish, and after several years of trial-and-error methods an efficient grader has been made.

Figures 1 and 2 show the present working model of the grader set in the specially designed live box, which is divided into three sections. The first section on the right is for the small fish, and the center section is for the "mediums"; the large fish go over the end of the grader into the third section on the left. The two chains attached to one end of the grader are for regulating the slope of the grader: the smaller the fish, the more slope is required. Figure 2 shows the extremes to which the grader can be set. By turning the eyebolts, in this model, steel wedges (made from angle iron) are raised and the wings are expanded; by turning the eyebolts in the opposite direction, the wedges are lowered and the wings are contracted by small springs attached underneath. The method of adjustment has been greatly simplified in the drawing. It will be noted in the plan that all the eyebolts have been eliminated and wooden dowels have been substituted. The eyebolts served to adjust the grader and acted as pivot posts to keep large fish from sliding crossways down the grader. As soon as fish come against a post they are turned parallel to the groove, and the wooden dowels serve the purpose well. With the new adjusters, the slots in each half of the grader are regulated in one movement of the arms on the outside of the grader. Each arm is attached to a shaft of half-inch pipe that runs through the grader, 2-1/8 inch under the wings. The quarter-inch rods attached to the shaft (see drawing) support a long tapered wedge (1/8 inch by 3 inches) which slides in and behind the wings on each section so that when the shaft is turned, all wedges move at the same time and all wings are expanded at once to change the slot openings. When the proper opening is reached, the arm can be locked in place with the set screw.

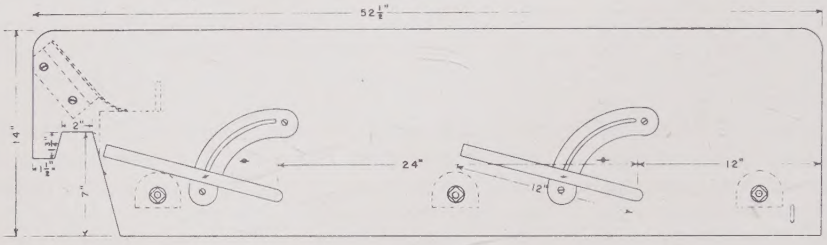
The most important step in adjusting the grader is to obtain an opening which will permit the best segregation of the fish to be graded. Such can be done by using a pair of outside- and inside-diameter calipers. From the fish to be graded, one is selected to represent the "smalls," and the outside-diameter caliper is adjusted snugly to the thickest part of the body of this fish. The inside-diameter caliper is then adjusted to the outside caliper and used as a thickness gauge to which the upper half of the grader slots are adjusted. The next step is to select a fish to represent the fish in the



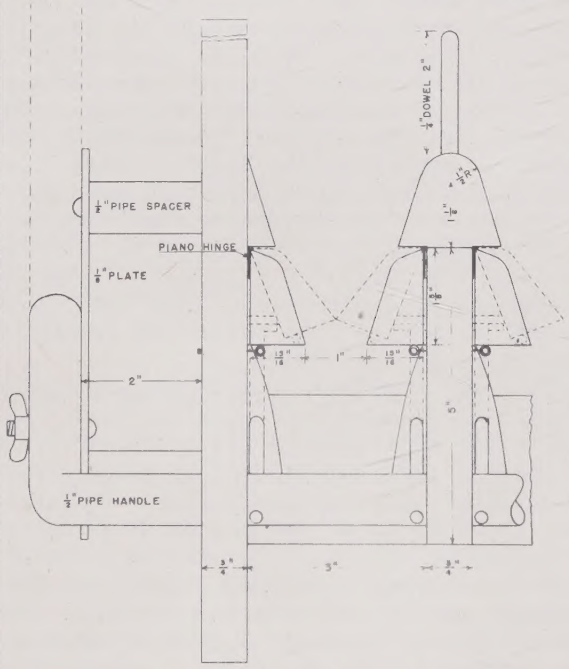
PLAN

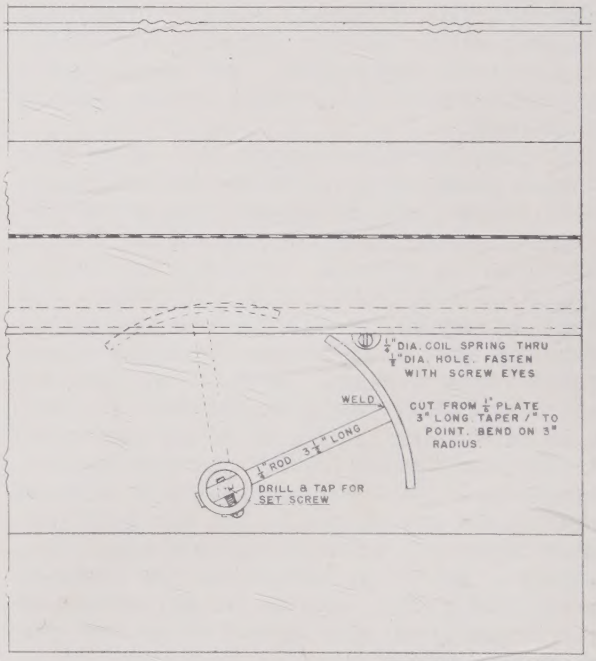


END VIEW



SIDE VIEW




¼" DIA. COIL SPRING THRU ⅜" DIA. HOLE. FASTEN WITH SCREW EYES
WELD
CUT FROM ¼" PLATE 3" LONG TAPER ⅞" TO POINT. BEND ON 3" RADIUS.
¼" ROD 3½" LONG
DRILL & TAP FOR SET SCREW

DETAILS

FISH GRADER		
SCALE	PLATE	OF PLATES
DRAWN 2-5-53 BY GHC		
ENGINEER-K E MORTON		
CHECKED BY ASS'T DIRECTOR	806	
APPROVED BY DIRECTOR		

Oregon State Game Commission - Portland, Oregon

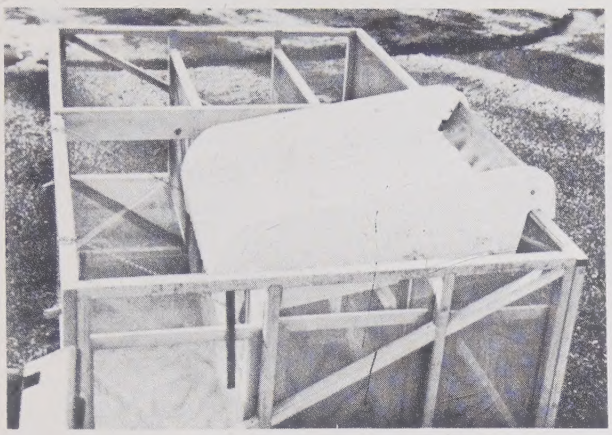


FIGURE 1.--The grader ready for operation in a live box (108 by 70 inches on the outside and 36 inches high) divided into 3 sections: the left-hand (for large fish), 24 inches wide; the middle (for medium-sized fish), 22 inches wide; the right-hand (for "smalls"), 17 inches wide. The slope of the grader is regulated by hooking chains in steel slots on the edge of the live box; then the space below the grader is filled with wood slats.

FIGURE 2.--The author turning eyebolts to regulate the size of openings. All of the upper half of the grader will be set exactly the same for the small fish to drop through; the lower half will then be set slightly larger for the medium-sized fish. The grader can be set to a thousandth of an inch.

(Photographs by Tom McAllister, Oregon State Game Commission)

medium-size group. It should be borne in mind that all fish larger than those in the medium-size group will go over the end of the grader as fish of largest size. When the medium size is selected, the lower half of the grader is adjusted in the same manner as the upper half, except that the openings will be slightly larger. The grader should then be thoroughly wet down with a hose, and a few fish run through in order to insure that the proper grading is being accomplished. Once the grader is set up, it will grade much faster than fish can be weighed out at the opposite end. The arrangement shown in the pictures was designed to permit a continuous operation.

Figure 3 shows the fish being graded into one end of the live box while one man weighs the respective size groups from the other end and two men carry the tubs of fish to their respective size-group ponds. The dip net is moved back and forth across the upper end of the grader as the fish are poured onto a rubber flap in order to prevent fish from piling up in one groove. The man with the hose flushes all stragglers on through the grader during the interval between dip-net loads. The grading action is positive and fast. There is no give to the wings, and the fish either drop through or go over the end.

At first glance the method may seem hard on fish, but well over 200,000 fish--from small fingerlings to 10-inch fish--of different species have been graded and held for months with no mortality that could be assigned to grader injury.

The fish being graded in figures 3 and 4 were a group of spring rainbow trout that were 11 months old from the day they started feeding. The group of 35,410 fish (5,921 pounds) was graded in 6 hours with a 5-man crew. In the operation, on April 16, 1952, the fish were divided as follows:

*2,531 pounds	- Large at	3.24 per pound	- 8,200
3,000 pounds	- Medium at	6.60 per pound	- 19,800
390 pounds	- Small at	19.00 per pound	- 7,410
Total mortality in group until planted, August 14, 1952 - 38			

*All stocked in April.

A small group of salmon, 10 months old from the day they started feeding, were graded on March 27, 1952, as follows:

32 pounds	- Large at	18.6 per pound	- 595
35½ pounds	- Medium at	60.5 per pound	- 2,158
3 pounds	- Small at	109.0 per pound	- 327

On October 29, 1952, we graded a large group of small rainbow trout fingerlings. Because of our constant spring water temperature (50° F.) and the consequent rapid growth, we hold the last of the spring eggs available from our high lakes--from which

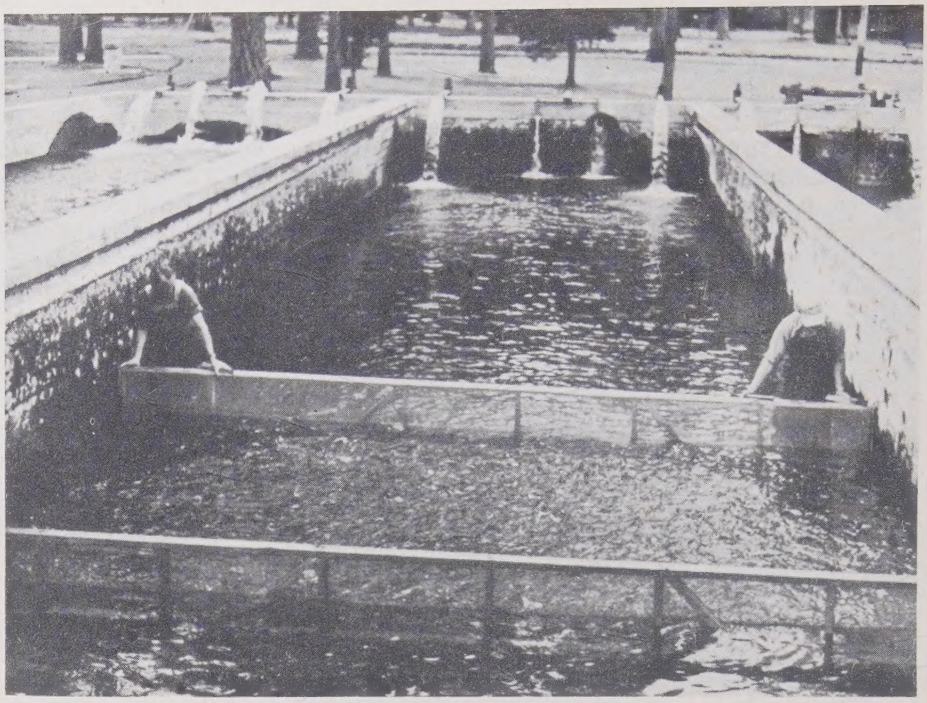


FIGURE 3.--All the fish in this pond are held between two crowders. After the fish have been graded, the medium-sized fish will be returned to this pond above the crowder, large fish will be put in the right-hand pond, and small fish will be put in the left-hand pond. The fish already in the right- and left-hand ponds were held by a crowder in just one-half of the pond until they were graded, an arrangement leaving the upper half of each pond to receive graded fish.

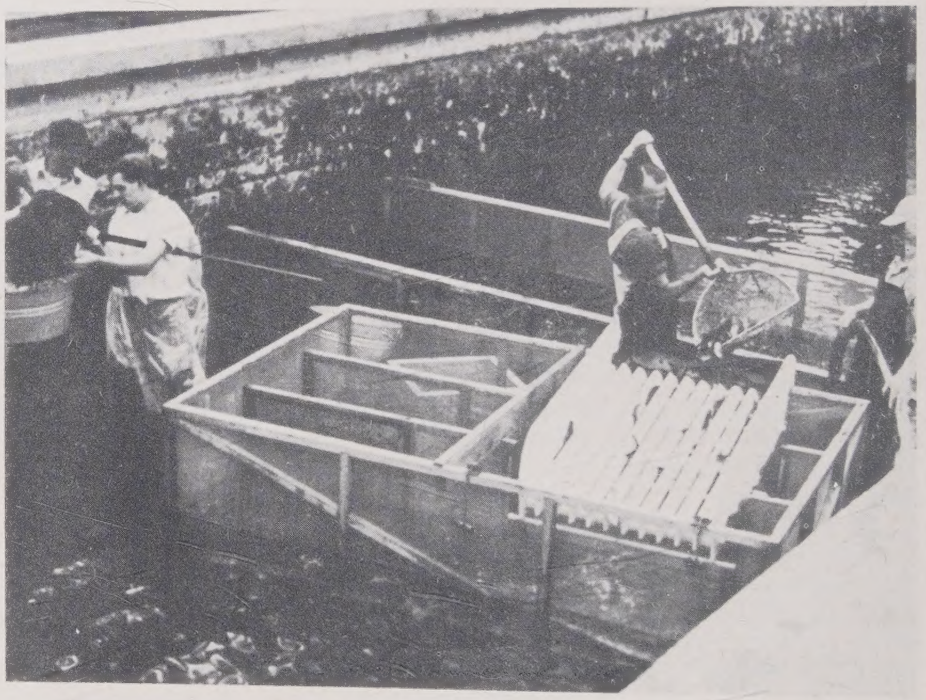


FIGURE 4.--To the left, where extra space permits continuous operation, fish are weighed. To keep fish from piling up in any one slot, the dip net is moved back and forth across the grader as the fish are poured onto the rubber flap of the grader. The 2-inch hose held by the man on the right is used to flush stragglers through the grader. The grader segregated nearly 6,000 pounds of fish in 6 hours, faster than the fish could be weighed.

(Photographs by R. L. Borovicka, Oregon State Game Commission.)

our yearling stock is produced. The fry began feeding on July 19, 1952, and measured 114 per pound on the last day of September. When graded on October 29, 1952, they were divided in the one grading into the following size groups:

806 pounds	- Large at	52.5 per pound	- 42,315
861 pounds	- Medium at	72.2 per pound	- 62,164
217 pounds	- Small at	97.2 per pound	- 21,092
		Number of fish in lot	- 125,571

A delayed mortality of 826 fish occurred 24 to 48 hours after grading--a mortality similar in nature to the delayed loss that

occurs at times in stocking fish and that has occurred at some hatcheries in merely transferring fish from one pond to another. It is not thought that the grader was entirely responsible for the loss. Losses for the group consisted of 28 fish in November, 15 in December, and 18 in January.

The small-size group of this same lot of rainbow trout was regraded on March 11, 1953, as follows:

660 pounds - Large at 11.0 per pound	-	7,260
391 pounds - Medium at 20.0 per pound	-	7,820
151 pounds - Small at 35.8 per pound	-	5,406
Number of fish in lot	-	20,486

There was no mortality to speak of from this second grading. It is possible that nine size groups will result from the two gradings. With one grading late in the fall and one additional grading in the spring, just prior to the start of the liberation season, an excellent size segregation can be had that will fit in very nicely with the liberation program as it progresses through the spring and summer months.

Listed here are the advantages and disadvantages of the grader.

Advantages

A much better segregation of size groups can be obtained with less handling of the fish than with most conventional graders.

The grading action is fast and positive, and there is no waiting for the fish to swim through bars as they must in some graders.

The grader is rigid. There is no give, which in rod-type graders often allows some large fish to get in with the small ones.

Once the grader is assembled, it is adjusted by moving just two levers for settings in minute fractions of an inch.

As uniformity is obtained in the size of fish in a pond, accuracy in counting them increases. The total weight of fish in any one group can be more accurately determined for purposes of computing the amount of food to feed in percentage of body weight.

Substantial savings in food, transportation, and stocking cost can be made if a size limit is not exceeded, as, for example, five fish per pound. In order to stock fish from April through August and not exceed the limit set, close and accurate grading of the fish is important.

There is considerable difference between a fast-growth diet and a maintenance diet. The large-size, ready-to-release fish can be successfully fed once every 2 or 3 days without fear of loss from cannibalism if the fish are accurately graded.

A much better distribution of fish among anglers can be had if large over-size fish are avoided.

It has been said that the graded "smalls" are runts and will not grow. This has been proved untrue at this station, although their growth rate is slower.

Disadvantages

The grader is a little complicated to construct and must be built with precision.

The live box is rather large and awkward to handle, but it has been used successfully in a circular pond with a diameter of 20 feet.

The writer hopes that at some future date an all-aluminum grader can be made that will have a water-hose attachment built in, with hollow main dividing sections with angular water jet ports at intervals down the sides of each slot, and thus eliminate the man with the hose.

DAMAGE BY THE SEA LAMPREY

The alarming decline of the lake trout fishery on the Great Lakes in recent years may be regarded as a direct result of the great destructive capacity and the great abundance of the sea lamprey.

The destruction of which this predator is capable is indicated by the fact that sea lampreys which were held in laboratory aquaria for the Great Lakes Fishery Investigations of the U. S. Fish and Wildlife Service killed an average of 17 pounds of fish during the parasitic phase of their existence. Further, in the Ocqueoc, just one of the rivers of the Huron Basin, 24,643 adult lampreys were counted as they passed a weir on the way to their spawning ground. On the basis of the findings in the laboratory aquaria, it is estimated that this single run of lampreys must have destroyed about 419,000 pounds of fish. And there are at least 150 such spawning streams tributary to the United States waters of Lakes Huron and Michigan.

EFFECTS OF TRANSPORTATION OF GREEN EGGS, AND OF WATER TEMPERATURE DURING INCUBATION, ON THE MORTALITY OF CHINOOK SALMON

Harlan E. Johnson and Richard F. Brice
U. S. Fish and Wildlife Service
Cottage Grove, Oregon

THIS REPORT COVERS ONE PHASE of an investigation designed to determine the effects of water obtained from Dorena Reservoir on salmon and trout in the egg, fry, and fingerling stages. In September 1950, green eggs of both spring- and fall-run chinook salmon (Oncorhynchus tshawytscha) were obtained at other hatcheries and were transported to the Dorena Dam Experimental Laboratory for hatching and rearing. The losses during the egg, fry, and early fingerling stages were extremely high in both lots: total mortalities were approximately 95 percent in the spring chinook and 75 percent in the fall chinook salmon. The three most logical explanations advanced for the losses were (1) high water temperatures (60° to 66° F.) during the incubation period, (2) some substance in Dorena Reservoir water that was toxic to salmon eggs and fry, and (3) handling and transporting the newly taken eggs.

During the 1951 spawning season, experiments were set up with both spring and fall chinook salmon eggs to determine whether any or all of the conditions listed above could be the cause of the abnormal mortalities. Again in the fall of 1952, the parts of the previous experiments relating to the effects of water temperatures on salmon eggs were duplicated to confirm the results obtained with eggs of the 1951 brood.

1951 EXPERIMENTS

The design of the experiment was essentially the same for both spring- and fall-run chinook salmon. The eggs were taken by the regular spawntaking crews and fertilized, and the excess milt was washed from the eggs. Then 30,000 eggs (estimated) were immediately divided at random into several equal sections. The eggs in section A were placed in a conventional egg basket, and those in the other five sections were placed in wide-mouthed glass jars of 1-gallon capacity. The jars, which were approximately half full of eggs, were then completely filled with water and sealed with a watertight lid. This is the method Burrows recommended (1949) for packing green eggs for transportation.

The eggs in each section were treated as follows, the water of various temperatures being obtained from intakes at three levels in Dorena Reservoir:

Section A. Eggs placed in conventional basket and held at originating hatchery until eyed.

Section B. Jar of eggs placed in water in hatchery trough (to keep the eggs cool) for several hours, and then eggs poured into basket at originating hatchery and held until eyed.

Section C. Jar of eggs hauled in truck for several hours and then returned to originating hatchery, placed in basket, and held until eyed.

Section D. Jar of eggs hauled to Dorena Dam Hatchery in truck, and eggs placed in basket in a trough supplied with the coldest water then available from Dorena Reservoir.

Section E. Jar of eggs hauled to Dorena Dam Hatchery in truck and placed in basket in trough receiving water similar to that in section D but which had been cooled 5 to 10 degrees.

Section F. Jar of eggs hauled to Dorena Dam Hatchery in truck and placed in basket in a trough supplied with the warmest water available. (Fall chinook salmon eggs were not included in this section.)

The eggs in section A were treated in the conventional manner at the hatchery where they were taken, and thus they formed the control groups for the experiments. Section B was designed to reveal any losses resulting from holding the eggs in the sealed container, and section C was to indicate the mortalities resulting from transportation of the eggs by truck while they were held in the sealed jar. The mortalities of eggs in section D included mortalities from all causes and would be the losses that could be expected at Dorena under normal operating conditions. The eggs in section E were held in the same water supply as those in section D, but for section E this water was first cooled by being passed through coils of plastic hose within a refrigerated box. As the resulting water temperatures were within what are considered to be the tolerances of chinook salmon eggs, any abnormal mortality could be charged to transportation and handling or to a toxic substance in the water. The results with the eggs in section F (included only in the spring chinook salmon experiment) were to reveal the effects of water temperatures higher than those encountered in the other sections. The eggs transported by truck were cooled while enroute by ice placed around the outside of the jars. Water in the jars was not changed or aerated at any time until the eggs were removed.

Water Temperatures

The daily mean temperatures of the water used for incubation of the eggs and fry in sections D, E, and F during September, October, and November 1951 are shown in figure 1. During the remainder of the experiment, the mean water temperatures for all sections at Dorena ranged from 48.0° to 37.0° F. The diurnal variations in temperature did not exceed 4 degrees in sections D and F and were usually only 1 degree. The daily range was somewhat higher in section E because of variations in the efficiency of the refrigeration unit used for cooling the water, but the maximum was not more than 7 degrees. The water used in section D was colder than any available the previous year and had mean daily temperatures of 60° F. or higher on only 12 days. This water was cooled 5 to 10 degrees for use in section E and had a maximum daily mean temperature of 53.5° F. during the experiments. The water temperatures during the incubation of the spring chinook salmon eggs in section F corresponded closely with those encountered in 1950 when the mortalities were very high. After October 20, water used in section F was from the same supply as that for section D; and after November 17, when cooling of water for section E was discontinued, all sections at Dorena were held in the same supply.

Fall Chinook Salmon

The eggs used in this part of the experiment were taken at the Spring Creek Hatchery of the U. S. Fish and Wildlife Service on September 26, 1951. The eggs in section B were held for 6½ hours in the sealed jar, which was placed in a trough of running water to keep the eggs cool, and were then poured into the egg basket. The jar of section C eggs was hauled in a truck for 6½ hours and then returned to the Spring Creek Hatchery, where the eggs were placed in a basket. The trip to the Dorena Dam Hatchery for sections D and E took about 6 hours.

On October 30, the eggs in sections A, B, and C at Spring Creek reached the eyed stage. They were shocked, the dead and infertile eggs were removed, and all eggs were counted. Those in section A, the controls, were then taken to Dorena in an eyed-egg transportation case, and incubation was continued in water below 55° F. As no unusual mortalities had occurred, sections B and C were terminated at this time. The eggs in the sections incubated at Dorena were also shocked, picked, and counted upon reaching the eyed stage, which occurred on October 15 in section D and on October 22 in section E. After the eggs hatched, the fry were allowed to develop while held in the basket until they were ready to feed, at which time they were released into the troughs and fed a diet of 100 percent liver. This experiment with fall chinook salmon was closed on March 20, 1952, after all sections had been feeding for several weeks and mortalities had reached normal.

The results of this test, summarized in table 1, indicate that neither transportation for a period of more than 6 hours nor incubation in water from Dorena Reservoir cooled to below 54° F., increased the mortality over that of the control group of fall chinook salmon. Mortalities of eggs, fry, and fingerlings in section E, which had been hauled by truck to Dorena while in the green stage and then incubated in the cooled water, were less than the mortalities in the controls, which had been held at Spring Creek until eyed and then had been brought to the Dorena Dam Hatchery for further incubation. The total mortality of 9.5 percent in section E is considered satisfactory and within the normal range of production hatchery results.

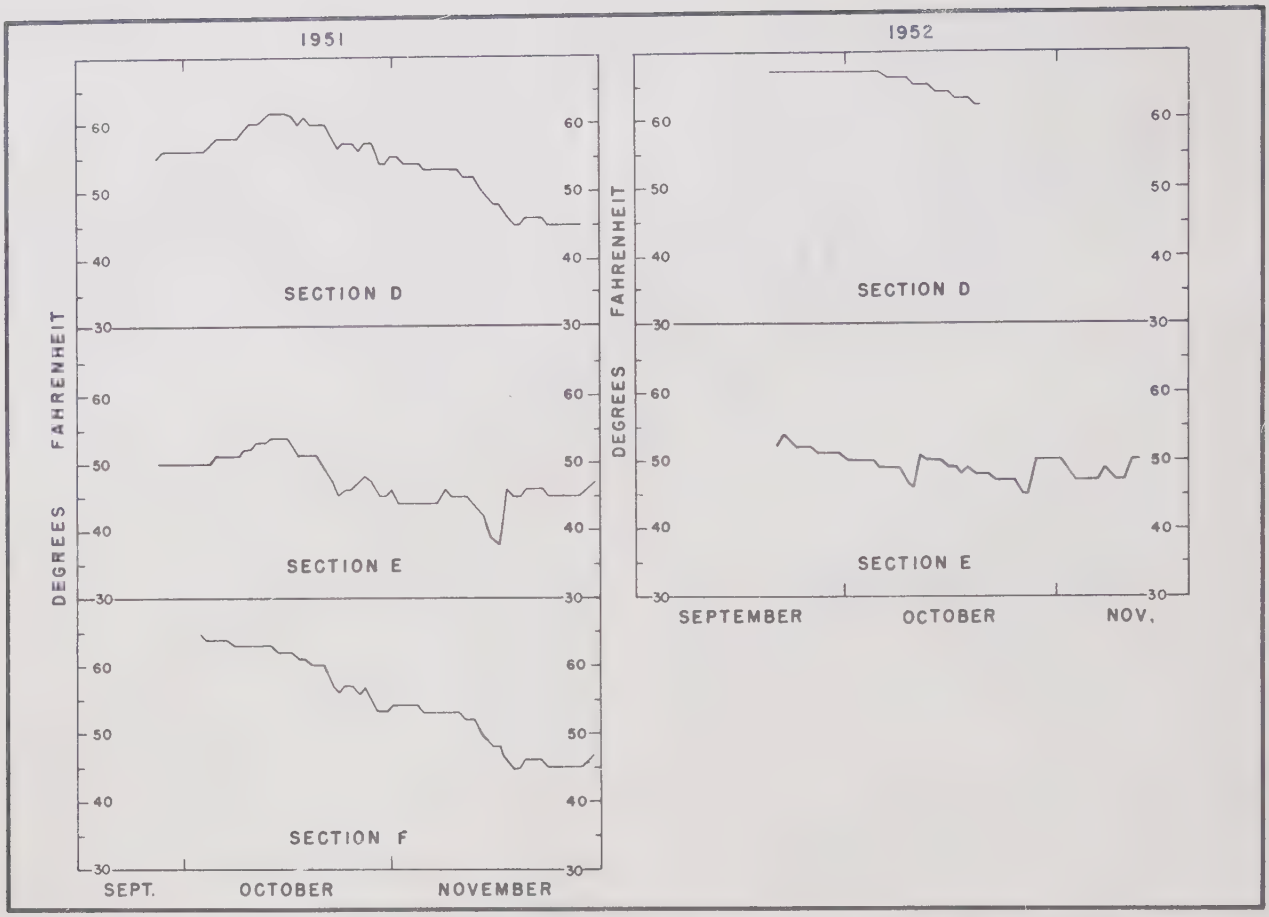


FIGURE 1.--Mean daily temperatures of water in egg incubation experiments, 1951 and 1952.

The increased mortalities of eggs and fish in section D were the result of the higher water temperatures during the early part of the incubation period. The adverse effects of these high water temperatures continued to be reflected in the mortality data through the fry and early fingerling stages. "Coagulated yolk" disease caused much of the mortality during the feeding period.

Spring Chinook Salmon

The spring chinook salmon eggs for this portion of the experiment were obtained at the South Santiam Hatchery of the Oregon Fish Commission on October 1, 1951. The eggs in sections B and C were held in sealed jars for 2½ hours before being placed in the egg baskets at South Santiam. Sections D, E, and F were enroute to Dorena by truck for 2½ hours. The eggs in section D were placed in the coldest available water supply, which was about 55° F. at that time; and the eggs in section E were placed in water that came from the same supply but which had been cooled several degrees. Section F eggs were placed in a trough supplied with water that then had a temperature of about 65° F., the warmest supply available.

On October 29, the eggs left at the South Santiam Hatchery reached the eyed stage. They were shocked, picked, counted, and then transferred to Dorena, where incubation was continued in a water supply that had an average daily temperature of 55° F. or less. Of the eggs in the sections brought to Dorena while in the green stage, those in section D were

TABLE 1.--Percentage mortalities of fall chinook salmon by stages of development, September 26, 1951, to March 20, 1952

Section	Number of eggs	Percentage mortality				
		Green eggs	Eyed eggs	Fry	Fingerling	Total
A	5,237	3.6	3.6	0.8	4.6	12.1
B	5,213	3.3	-	-	-	-
C	5,142	4.2	-	-	-	-
D	5,011	3.9	6.3	3.7	4.8	17.5
E	5,390	3.6	3.2	0.7	2.3	9.5

TABLE 2.--Percentage mortalities of spring chinook salmon by stages of development, October 1, 1951, to March 20, 1952

Section	Number of eggs	Percentage mortality				
		Green eggs	Eyed eggs	Fry	Fingerling	Total
A	4,507	19.6	23.8	1.3	5.9	43.1
B[1/]	4,199	19.8	23.6	2.5	5.3	43.2
C	4,311	19.4	26.6	1.8	4.4	44.5
D	4,139	26.0	26.5	2.8	7.8	51.3
E	4,304	21.2	27.2	1.3	2.7	45.0
F	4,055	34.5	48.8	28.8	14.9	79.6

[1/] Does not include mortality of 200 fry from smothering.

eyed on October 19, those in section E were eyed on October 28, and those in section F on October 17. These eggs were also shocked, picked, and counted when they were well eyed. The fry and fingerlings were handled in the same manner previously described for fall chinook salmon. This experiment was also closed on March 20, after all sections had been feeding for some time.

The mortalities in all sections, presented in table 2, were much higher than the mortalities encountered in the experiment with fall chinook salmon eggs. Again, the warmer water during the incubation period had a deleterious effect on the survival of the eggs. Section F, which was held in the warmest water, had by far the greatest mortality. Section D, held in the normal water supply, suffered somewhat higher losses than the eggs held in the cooled water of section E, which had mortalities comparable to those of the controls. Holding and transporting the spring chinook salmon eggs in sealed containers had no adverse effect on the eggs, as evidenced by mortalities in sections B and C, which were similar to those in the control group. As in the fall chinook salmon, "coagulated yolk" disease caused part of the fry and fingerling mortality in all sections but was especially prevalent in section F. Fish in this condition were seen until shortly before the experiment was closed.

In all sections of both spring and fall chinook salmon, the mortalities during the eyed stage were quite high in comparison with the green egg losses. This is believed to be mainly the result of ineffective shocking of the eggs at the time they reached the eyed stage, with the result that only part of the infertile eggs turned white at that time. The dead eggs that were removed during the eyed stage were examined, and it was found that many of the eggs contained no evidence of an embryo and apparently had never been fertile.

1952 EXPERIMENTS

The parts of the experiment dealing with the relation of water temperatures during incubation to mortalities were repeated with fall and spring chinook salmon eggs of the 1952 brood. This experiment was terminated soon after the eggs reached the eyed stage, as the hatchery at Dorena Dam was closed at that time.

Water Temperatures

The only water available from the hatchery water supply lines, as used in section D in 1952, had daily mean temperatures (figure 1) of 62° F. or higher during the entire period this section was in operation, and for the first 3 weeks the minimum temperature recorded was 65° F. The water for section E was again cooled by passage through plastic coils in the cold-storage box. The maximum daily mean temperature in this section was 53.5° F., and for much of the incubation period the water temperatures were below 50° F.

Fall Chinook Salmon

The fall chinook salmon eggs of the 1952 brood were taken at the Little White Salmon Hatchery of the Fish and Wildlife Service on September 24. Some of the eggs selected for the experiment were placed in a hatching basket at Little White Salmon as the control group. The remaining eggs were divided between two glass jars and then were hauled to Dorena (a 6½-hour trip), the methods used being the same as those described for the 1951 test. The eggs from one jar were placed in a trough supplied with the coldest water then available (section D). This water was much too warm for the eggs, and they started dying within a few days. Eyes of the embryos appeared in a few of the eggs, but they were not normal, and none of the fry hatched. This section suffered 100 percent mortality by October 20 (table 3). The green fall chinook salmon eggs in the second jar transported to Dorena were placed in the cooled water

TABLE 3.--Percentage mortalities of fall chinook salmon by stages of development, September 24, 1952, to November 12, 1952

Section	Number of eggs	Percentage mortality		
		Green eggs	Eyed eggs	Total
A	14,143	3.7	-	3.7
D	5,024	84.5	100.0	100.0
E	5,320	3.0	0.6	3.6

supply of section E, where they developed in a normal manner. There had been a total mortality of 3.6 percent in this section when it was closed on November 12, after the eggs were well eyed. The control eggs in section A, left at Little White Salmon, reached the eyed stage on November 5. The section was closed November 12, at which date there had been a total mortality of 3.7 percent. This experiment again indicated that water from Dorena Reservoir was too warm for incubation of chinook salmon eggs but could be made suitable by adequate cooling.

Spring Chinook Salmon

Spring chinook salmon eggs of the 1952 brood were obtained from the Oakridge Hatchery of the Oregon Fish Commission on September 20. Approximately one-half of the eggs were left at Oakridge as the controls, and the remainder were taken in two jars to Dorena (a 2-hour trip) by truck. The eggs from the jar for section D had suffered 100 percent mortality from high water temperatures by October 17 (table 4). Weak eye spots were observed in a few of the eggs, but they all died before hatching. The eggs from the other jar were incubated in the cooled water of section E. This section reached the eyed stage on October 20 and was terminated on November 5. The mortality in section E was 2.6 percent. The control eggs in section A, incubated at Oakridge, were eyed about October 18; this section was also closed on November 5. The total mortality in section A was 2.3 percent. These results indicate that temperature was the critical factor in incubation mortalities at Dorena.

TABLE 4.--Percentage mortalities of spring chinook salmon by stages of development, September 20, 1952, to November 5, 1952

Section	Number of eggs	Percentage mortality		
		Green eggs	Eyed eggs	Total
A	13,803	1.9	0.4	2.3
D	6,674	95.4	100.0	100.0
E	7,370	2.3	0.3	2.6

CONCLUSIONS

Newly taken fall chinook salmon eggs placed in glass jars filled with water and sealed with watertight lids were not adversely affected by truck transportation for 6½ hours. Similarly, spring chinook salmon eggs were not adversely affected by transportation for 2½ hours.

Water from Dorena Reservoir was suitable for incubation of spring and fall chinook salmon eggs and fry when daily mean temperatures were below 54° F.

Chinook salmon eggs incubated in Dorena Reservoir water that had temperatures over 60° F. suffered excessive mortality.

These experiments produced no evidence of any toxic substance in Dorena Reservoir water that might be harmful to chinook salmon eggs, fry, or fingerlings.

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HELPFUL HINT FOR CARP CULTURISTS!

"Carp is the most valuable of the finny tribe, for stocking ponds ..."

In a treatise devoted to the management of this highly esteemed species, the editor of The Domestic Encyclopaedia, or, A Dictionary of Facts and Useful Knowledge (Philadelphia, 1803) carefully outlined a number of desirable practices and recommended the following procedure for use during severe winter weather:

"... the fish may be preserved in a cellar, by the following expedient: Let each be enveloped in wet moss laid on a piece of net, and then be secured in a purse, so as to admit the air. The net must be immersed in water, at first every third or fourth hour, and suspended to the ceiling, though afterwards such dipping may be performed once in six or seven hours. Their food ought to consist of bread, soaked in milk, which should be given in small quantities, and gradually increased, as the animal becomes accustomed to this mode of living. By such treatment many fish have been preserved alive for a considerable time, and have even grown fat, so as to become more fit for the table."

EXPERIMENTS WITH

NIGROSINE DYE IN AQUATIC PLANT CONTROL

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ALTHOUGH THE LITERATURE on aquatic weed control with nigrosine dye is not so well documented as that on the control of aquatic plants by other means, a perusal of the literature leaves one with the impression that this method of control warrants further study. Eicher (1947) reported on its use in Arizona lakes, and Surber and Everhart (1950) reported on its biological effects in a fish hatchery pond. The experimental work here reported encompasses a lake study, numerous jar tests in the laboratory, and a fish hatchery pond.

LOON LAKE

The lake chosen for the nigrosine experiment was Loon Lake in the Michigan Department of Conservation's Rifle River Area, Ogemaw County. The lake is mainly spring-fed, and in normal years the evaporation and seepage equal the supply so that little water is lost through the outlet. Loon Lake is set fairly low, surrounded by hills, so that it is not exposed to the wind action which is developed on larger, more open lakes. The turbidity was greater, in general, than that of the other lakes in the area. Practically all the plants in the lake were growing within the 5-foot contour. Although all the lakes in the area were open to fishing, this lake was the least used because the weeds interfered with rowing and fishing. The methyl orange alkalinity was about 100 ppm., and the pH of 8.0 indicated a fairly alkaline condition.

This is a condensation of a portion of a thesis presented to the Graduate School of Michigan State College in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 1951. The study was sponsored by the Institute for Fisheries Research, Michigan Department of Conservation, in cooperation with the Department of Botany and Plant Pathology, Michigan State College.

At the time of the application of the dye, the water level of this lake was at least 6 inches below normal because of a very dry spring. Anacharis canadensis plants in several areas were so heavily coated with marl that they were bent over and did not interfere with rowing. A large patch near the outlet, although discolored by marl, was just about to the surface and slowed up a boat drifting through it. Ekman dredge samples were taken in the deeper waters, and it appeared that no rooted aquatic plants were growing in water more than 10 feet deep. The soft, pulpy peat on the bottom made it difficult to determine the exact depth of the water.

The main weed species were as follows:

Anacharis canadensis
Chara spp.
Myriophyllum verticillatum
Nuphar advena
Potamogeton zosteriformis
Vallisneria americana

Application of the dye (National Nigrosine No. 128-B) to Loon Lake was made on July 17, 1948, at the rate of 15 pounds per acre. In making the application, the dye was divided into three parts and distribution was made by sprinkling the dry granules off the stern of a moving boat in three lanes which traversed the length of the lake. The water in the wake of the boat colored immediately, and diffusion was fairly rapid. In the course of a few hours, the currents had so merged the color that the lanes were scarcely perceptible. Coverage was considered complete in 24 hours.

Before the application of dye, the Secchi disk had disappeared at 5 feet. Twenty-four hours later, the reading was 3 feet in open water. In the shallows, the marl-coated Anacharis canadensis plants were conspicuous against the blackness of the water.

The lake again was examined on August 13, at which time the Secchi disk disappeared at 5 feet 6 inches. The personnel at the

area had periodically taken Secchi disk readings, and these indicated a gradual increase in transparency over the intervening period. The marl-coated Anacharis canadensis plants did not appear to have been affected by the brief period of darkness, as the leaves were of a normal green color when the lime was removed. Eelgrass (Vallisneria americana) had become conspicuous in several areas, and the terminal portions of Ceratophyllum demersum were within a few inches of the surface.

Owing to the method of application, it was suspected that some of the crystals might have fallen into the layer of very light and fine pulpy peat and become buried. To establish whether these crystals existed and had formed a heavy dye solution which would not diffuse through the pulpy peat, the following test was made on August 13.

One of the lanes, made when the crystals were distributed, had begun within a cove and passed out into the lake proper. A furrow, 10 to 15 inches deep, was dug in the pulpy peat across the mouth of the bay, at right angles to the lane of crystals and necessarily crossing it. The stirred peat settled rapidly so that by the time the furrow was finished, the water looked normal where first disturbed. This was in water about 1.5 feet deep. No blue coloration persisted in the water after the silt had settled.

On September 25, the Secchi disk disappeared at 7 feet. The water level was down about 10 inches because of the dry summer, and several weed beds which previously had not come to the surface had now contacted the surface. For a comparison of the growth of plants, stakes had been put in to mark the extent of two beds of Chara and one of Anacharis canadensis; and there was evidence from the spread of these beds that their growth had not been retarded by the application of the dye. The marl, by this time of the year, had become so heavy on Anacharis canadensis especially that the plant no longer interfered with rowing, as it was lying almost prostrate on the bottom. When portions of the plants were shaken free of marl, the leaves were seen to be of a normal green color; and when these examined plant fragments were returned to the water, they did not sink immediately but remained seemingly suspended. This indicated that they were on the bottom because of the weight of the marl deposition. At this inspection samples of the water, of the plants, and of the pulpy peat were secured for laboratory study in an attempt to determine the cause of the disappearance of the dye.

LABORATORY EXPERIMENTS

After the failure of nigrosine to control or kill the plants in Loon Lake, experiments were made to determine the cause of the disappearance of the dye. In one of these experiments, a quantity of pulpy peat from the bottom of Loon Lake was allowed to drain and to dry. A 2-inch layer of this dry peat was placed in each of three milk bottles. They were then filled with lake water. Equal-sized crystals of nigrosine were dropped into each bottle. The crystals fell through the water and sank into the pulpy peat of the bottom. One bottle was shaken vigorously so that the peat was completely suspended and the nigrosine was put into solution. The two other bottles were allowed to stand. Two days later the water in the milk bottle which had been shaken was still blue with dye and the pulpy peat had settled to the bottom. The bottles that had not been shaken were still clear. Eight days after the experiment had been set up, the two undisturbed bottles had not colored. One of these was then shaken vigorously. After the peat had settled, the water was bluer than that in the bottle which had been shaken at the start of the experiment. Subsequent shaking of the latter bottle and allowing it to stand did not regenerate the original intensity of color.

To determine whether the presence of mud would cause or be a factor in the clearing of dye solutions, a series of jar tests was begun. The first was set up January 18, as follows:

Four 1-gallon wide-mouthed jars were set up, each with 3,500 milliliters of tap water which had been allowed to stand. To each, respectively, the following materials were added:

Jar No.	Dry peat (grams)	Dye No. 128-B (grams)	Parts per million
1	10	0.02	5.7
2	25	.02	5.7
3	25	.07	20.0
4	50	.07	20.0

The concentration of dye in the first two was so low that it was impossible to obtain a reading in the modified turbidimeter. A reading of the other two was 275 millimeters. After the jars were set up, each was stirred vigorously every day.

By January 31, 13 days after the jars had been set up, jar No. 2 was clear except for the stain due to the peat. Jar No. 1 was stained likewise but, in addition, still had

TABLE 1.--Clearing of dye solutions determined by turbidimeter readings

Dye	Concentration (in ppm.)	Turbidimeter reading (length of liquid column in mm.)						
		1/14/50	2/6/50		3/8/50		4/7/50	
		Stirred	Unstirred	Stirred	Unstirred	Stirred	Unstirred	Stirred
1	285.7	120.0	130	120	150	140	120	110
4	71.0	250.0	300	[1]/ 310+	310+	310+	310	-
5	71.0	180.0	245	221	310+	260	290	233
6	86.0	217.0	255	225	305	240	310	250
7	57.0	219.0	307	264	310+	310+	310+	310+
8	14.0	265.0	277	260	307	305	310	305
ESB	14.0	278.0	302	300	310+	310+	310+	310
R-1155	14.0	278.0	280	280	310+	310	310	310
128-B	14.0	276.5	285	285	310+	310+	310	310

[1]/ Maximum possible reading was 310, so that readings of 310+ do not indicate equal absolute turbidities.

a slight bluish hue. No. 4 was cleared to the extent that no reading was possible.

A week later, Nos. 1 and 2 were unchanged. No. 3 was stained but had a slightly perceptible blue color. No. 4 was clear of dye but was stained.

In another 3 weeks, algae had increased to the extent of interfering with the experiments and thus the contents of the jars were discarded. No. 1 still showed a slight bluish hue. The amount of mud seemed to be a factor in the clearing of the solution.

As it appeared difficult to maintain this dye in solution, samples of dyes of different formulations were obtained (General Aniline and Film). In the comparison of the ability of these different dyes to maintain a solution, a series of nine 1-gallon wide-mouthed jars was used, each jar containing 3,500 milliliters of water. Into each of these jars was placed a measured quantity of dye from different experimental samples. The jars were placed on a bench in a greenhouse, and periodically the dyed water in each jar was tested twice with the turbidimeter. One reading was made of the water which was decanted, the other after stirring. The results are given in table 1.

The dyes were compounded differently and, owing to their inherent properties, they differed in ability to produce color. For example, half a gram of each of two dyes would not necessarily give equal color to equal volumes of water. The concentrations used were those which would make it possible to obtain a reading of the degree of light penetration by use of the turbidimeter. Any smaller amount of dye would have made such a dilute solution that it would have been impossible to obtain a reading in the modified turbidimeter. A high reading indicates a less deeply colored solution than a low reading.

Another series of jar tests was made to determine more accurately the effect of mud and plants on the clearing of dye solutions. Wide-mouthed 1-gallon jars, each containing 3,500 milliliters of lake water, were used. Into these (except the control jars, where no additions were made) was placed either a layer of mud, a handful of Anacharis canadensis, or a combination of these. Dye was placed in all the jars at known concentrations. These jars, with a cover of glass, were placed in the greenhouse and examined periodically.

Although eight differently formulated nigrosine dyes were used, a solution of every one could be cleared by plants or mud alone. In these jars evidence of nigrosine was to be found in one or all of three places: clumps of dye could plainly be seen on the leaf surface of the plants, entrapped or chemically associated with the precipitate of lime on the sides of the jars, and on the bottom of the jar in clumps or associated with lime deposits. The rate of clearing was proportional to the amount of plants present.

FISH HATCHERY POND

At the Hastings (Michigan) Fish Hatchery, pond No. 8 has produced annually a very luxuriant crop of weeds, chiefly Anacharis canadensis and Ranunculus flabellaris. This pond was used for the experimental rearing of bait minnows and had received artificial fertilization during the growing season. It was 0.75 acre in area and sloped to a depth of about 6 feet in the center and near the drain basin.

On June 21, 1950, 16 pounds of nigrosine (National Nigrosine No. 128-B) was put in the pond, an application at the rate of 21.3 pounds per acre. The dye was divided into three portions, and each portion was placed in a pail of water. The dye seemed to coagulate, forming large, hard lumps that slowly dissolved. The 16 pounds were distributed by walking around the edge of the pond in the

shallow water and periodically allowing the pail to fill with water, subsequently pouring out the dye solution but retaining the lumps of dye. By the next day the dye had colored the open water in the center, and distribution was considered uniform after 2 days.

Secchi disk readings were taken, from a box which enclosed the outlet at the deepest part of the pond, between the hours of 11:00 a.m. and 1:00 p.m. Just previous to the application of the dye, which decreased light penetration, the Secchi disk reading was 1 foot. On June 26, 5 days after the dye had been put in, the Secchi disk reading was 1.5 feet. This, therefore, indicated that the decreased penetration of light after application of the dye was only temporary.

A week after application of the dye, the shallow water appeared to be clearing and Secchi disk readings confirmed the suspicion that the dye concentration was not being maintained. When samples of the plants were examined, they showed black deposits, especially on the upper surface of the leaves of Anacharis canadensis.

Fertilizer was added on June 29.

On July 1, 3 weeks after the initial application, another treatment of 15 pounds was made. This dye was placed in the bottom of a 10-gallon milk can, which was then filled with water. By means of a portable power sprayer, the supernatant liquid was sprayed over the surface of the pond. As the level of the dye solution in the can fell, it was replaced with water taken from the pond until all the dye in the bottom of the can was dissolved. Unfortunately, the Secchi disk reading was not made at this time. A week later the reading was 1.5 feet, and on July 10 it was 2 feet.

On July 18, determinations of the oxygen and carbon dioxide concentrations of the water showed that the oxygen level was 1.1 ppm. and the carbon dioxide was 39.0 ppm. This and subsequent determinations were made between 11:00 a.m. and 1:00 p.m. The Secchi disk disappeared at 3 feet. With such a low oxygen content, there was concern for the safety of the sunfish which were in the pond for other experimental purposes. The water, which had been shut off to prevent dilution of the dye, was then allowed to run into the pond. Shortly after this, 2 days of heavy rain occurred, so that on July 21 the oxygen content was up to 4.2 ppm. and the carbon dioxide was down to 0.0 ppm.

In order to prove more definitely that the addition of the dye and subsequent coloring of the water can cause a depletion in the oxygen content of the subsurface water, an additional 15 pounds of dye was put in on August 4. At this time the water to the pond was turned off and the dye was distributed by means of a burlap sack of the crystals dragged behind a boat. The oxygen content at this time was 11.4 ppm.; the carbon dioxide, 0.0 ppm.

Three days after this application of the dye, the Secchi disk reading was 1 foot, the oxygen was down to 1.98 ppm., and the carbon dioxide concentration was up to 11.0 ppm. On August 11, the light penetration was 2 feet, the oxygen content at 2.6 ppm., and the carbon dioxide at 11.0 ppm. At this time another 15 pounds of dye was introduced by means of a cotton bag filled with crystals and

TABLE 2.--Effect of applications of nigrosine dye on oxygen, carbon dioxide, phenolphthalein alkalinity, methyl orange alkalinity, and depth of penetration of light

	June		July					August				
	21	26	1	7	10	18	21	4	7	11	18	25
Dye added (in pounds) ------	16.0	-	15.0	-	-	-	-	15.0	-	15.0	-	-
Oxygen (in ppm.) --------	-	-	-	-	-	1.1	4.2	11.4	1.98	2.6	2.3	-
Carbon dioxide (in ppm.) ----	-	-	-	-	-	39.0	.0	.0	11.00	11.0	14.0	-
Phenolphthalein alkalinity (in ppm.) ----	-	-	-	-	-	.0	4.0	13.0	.00	.0	.0	-
Methyl orange alkalinity (in ppm.) ----	-	-	-	-	-	24.0	132.0	144.0	142.00	167.0	178.0	-
Secchi disk (in feet) ----	1.0	1.5	-	1.5	2.0	3.0	-	1.0	1.00	2.0	-	2.0
Remarks --------	Water turned off.	-	-	-	-	Water turned on.	-	Water turned off.	-	-	-	Water turned on.

towed behind a boat. When plants were pulled from the deeper water (their tops were in the photosynthetic zone) for examination, it was noticed that the lower stems of Anacharis canadensis were bare of leaves. These stems were green, turgid but not brittle. An odor of putrefaction was noticeable around the pond. Bullheads were noticed in distress and seemed to be gulping for air at the surface on August 14. A week after this application of dye, the oxygen content was 2.3 ppm. and the carbon dioxide was 14.0 ppm.

It is quite likely that additional applications would have caused further reduction in oxygen concentration; as this might have affected the fish adversely, dye applications were terminated. There was apparently little or no effect upon the weeds (other than the bare stems), as they remained in a normal condition throughout the remainder of the summer. At the end of the growing season, seining operations were hampered by the abundant weeds, which had to be forked into piles as the water level was purposely lowered.

Results of the analyses of water samples and Secchi disk readings obtained during the course of dye treatments are shown in table 2.

SUMMARY

1. A field trial with nigrosine in a 7-acre lake, at the rate of 15 pounds per acre, was disappointing because the dye concentration was not maintained.

2. Laboratory experiments indicated that a solution of dye could be cleared by mud or plants alone. Eight experimental dyes were used, but they gave results no better than the dye used in the original field trial. Comparison of rates of clearing was made with the aid of a turbidimeter.

3. An experiment at a fish hatchery pond showed that weeds were not controlled, and that the dissolved oxygen concentration decreased to a point considered dangerous to the health of the fish population.

4. Disappearance of the dye from solution appeared due to a chemical reaction between salts in the water and the dye. This resulted in the formation of an insoluble precipitate which was visible as a bluish, granular deposit on the leaves of the plants and on the sides and bottom of the jars.

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SODIUM ARSENITE ON DRY POND BOTTOMS

The spraying of sodium arsenite on dry pond bottoms to control submerged aquatic plants (principally Najas) has resulted in better production and a saving of labor costs, according to R. M. Hiland, U. S. Fish and Wildlife Service, Farlington, Kansas.

In May 1951, sodium arsenite (4 pounds arsenous oxide per gallon) was applied to two 25- by 200-foot strips of dry bottom in a pond that would not produce a satisfactory bloom because vegetation absorbed the fertilizer. One strip was treated with 25 gallons of the sodium arsenite in a ratio of 1 to 1; the second strip was treated with 10 gallons in a ratio of 1 to 4. No vegetation appeared in the treated areas that season, and a good bloom was maintained. As a precaution, copper sulfate was used twice around the kettle before the pond was drained in July.

In June 1952, additional areas containing Najas were treated with sodium arsenite in the 1 to 4 ratio before the pond was stocked with bluegills. The stain from decay was very heavy, and an ideal bloom was maintained. Visibility on September 18 was only 14 inches.

The use of sodium arsenite on this dry pond bottom resulted in a saving of $100 in labor for the last two drainings, plus better production.

At the Farlington Station, spraying dry bottoms with sodium arsenite at the 1 to 4 ratio has been more effective than treating pond water with arsenite at 5 ppm. Even in the more expensive ratio of 1 to 1, the spraying of dry bottoms is less costly than the labor of raking. Treatment of areas with seepage is not effective, as the arsenite apparently is removed by the flow of water.

USE OF PECTORAL FIN RAYS TO DETERMINE AGE OF THE WHITE SUCKER

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THE WORK of E. G. Boyko (1946) on aging fish from sections of fin rays suggested the possible use of similar techniques for aging the white sucker, Catostomus c. commersoni (Lacépède). Considerable difficulty had been experienced in aging suckers from scales, and it was hoped that the use of spine or ray sections would serve as a supplemental or alternate method.

Scales and the right pectoral fin were removed from a series of suckers from Lake Washington, Blue Earth County, Minnesota, in January 1952. The fish were taken in winter so that there would be a maximum separation of the last annulus from the edge of the scale. Each fish was measured and weighed. Scales were taken from the third to fifth row of scales above the lateral line, in an area above the point of intersection of the pectoral fin and the lateral line. The right pectoral fin was removed at its base with tin shears. After being removed, the fin was placed in a scale envelope and allowed to dry.

When the fin had dried it was held firmly in the specimen holder of a hand microtome and transverse sections about 0.5 millimeter thick were cut from the marginal ray and from two succeeding rays with a fine-bladed jeweler's saw. The best sections were obtained from 0.125 to 0.25 inch above the base of the ray. In sections that were farther above the base, the first annulus was difficult to discern or was lacking. Usually sections of the second and third rays showed a more sharply defined growth pattern than the first or marginal ray. It is essential that the sections be cut at right angles to the axis of the fin ray.

Ray sections were cleared in xylene and then examined under a binocular microscope using low power. It was found that about 0.5 millimeter was the best thickness for this work: thinner sections did not show good differential transparency, and thicker sections transmitted light poorly. In these respects the sucker rays proved to be similar to those of sturgeon which were reported by Cuerrier (1951).

Transverse sections of the first three fin rays were examined from 20 suckers in age groups I, II, and III, and these sections were compared with scales taken from the same fish. The age of 17 of the 20 fish was determined to be the same from both scale annuli and fin-ray annuli. In the remaining 3 fish, poor cross sections made the comparison questionable. In the 17 fish for which good cross sections were available, the growth pattern was more sharply defined in the ray sections than it was in the scales. For several fish a number of scales had to be examined to ascertain the presence or absence of a first annulus, which was easily distinguishable in the fin-ray sections.

The accompanying photographs (see opposite page) show scales and fin-ray sections from two suckers: one in its second year (one annulus) and the other in its fourth year (three annuli).

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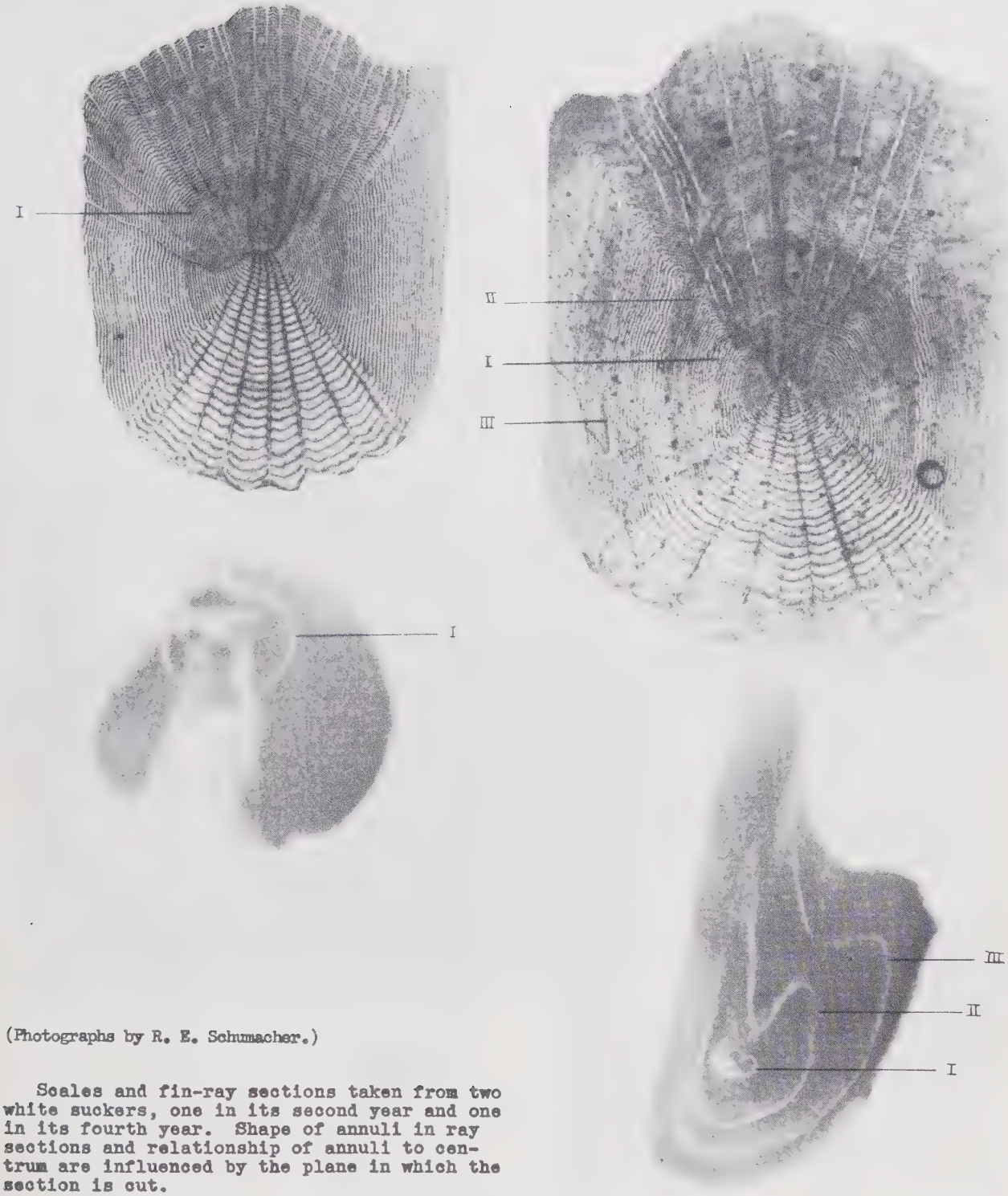

(Photographs by R. E. Schumacher.)

Scales and fin-ray sections taken from two white suckers, one in its second year and one in its fourth year. Shape of annuli in ray sections and relationship of annuli to centrum are influenced by the plane in which the section is cut.

"Some Roman epicures nourished pet breeds of fish, as cattle breeders perfect particular strains of blood."--Report, U. S. Commissioner of Agriculture, 1868.

A Report on the Fisheries of East Bengal, Pakistan

A. R. K. Zobairi
Deputy Director of Fisheries
Government of East Bengal, Pakistan

THE PROVINCE OF EAST BENGAL, comprising the eastern wing of the Dominion of Pakistan, is principally riverine in its geography. The Province is bounded in the north by the Himalayan mountain range and in the south by the Bay of Bengal. East Bengal is the flood plain of the Ganges River and its tributaries and a drainage basin for the numerous other smaller rivers that originate in the eastern mountain ranges bordering Assam and Burma. Most of this Province is a low-lying flat country subject to inundation during the monsoon months of May through July. The average annual rainfall in this region is about 84 inches.

The major rivers that flow through East Bengal empty into the Bay of Bengal and have formed at their mouths an extensive delta. It is an intricate network of canals and creeks interspersed with islands of alluvium and detritus brought down by the rivers. These islands are forested mainly with Rhizophora (mangrove) and two softwood species that in the local parlance are called "Sundri"--and have given the name "Sunderbans" to this area.

FISHERY RESOURCES

The Province of East Bengal, nearly half of it being inland water standing over rich alluvial soil, has immense inland fishery resources which have been developed and exploited systematically by private enterprise almost since time immemorial. The Department of Fisheries, a Government agency under the Ministry of Food and Agriculture, renders all possible technical advice and assistance to persons engaged in this industry. As for the marine fisheries of the Bay of Bengal, it is to be regretted that the necessary talent and enterprise for tapping this resource are lacking. The coastal inshore waters and the shallow littoral areas around islands in the bay are, however, fished commercially. The brackish-water labyrinth in the Sunderbans is also not exploited fully on account of its inaccessibility and inhospitable geography. The Sunderbans are the abode of the notorious Bengal tiger, which is a ruthless killer of man and beast. This single factor in itself has kept the ill-armed fishermen from most of the promising fishing grounds in this locality.

An average Bengalee, regardless of his religion, caste, or creed, is a fish culturist, a fisherman, and a fish eater. Among most of the people, fish is preferred to most other meat. The factors responsible for the development of this preferential taste are ostensibly two. In the first place, as the area is water-logged during the major portion of the year, there is not much pasture for raising beef and mutton in sufficient quantity. Barring poultry, there is not much livestock development in the country. Therefore, of necessity, man must depend on fin and feather for his protein nutrients. Secondly, rice is the staple diet in the region, and fish as a source of phosphorus and protein brings the meal closer to a balanced diet than any other. So, fish is in great demand all over the country. This has meant a greater effort at production of this commodity. In East Bengal, therefore, fish culture stands today on a par with agriculture.

Exact figures on total fish production in the Province are not available for the postpartition period. Collecting statistics is an expensive endeavour, and the infant state has not been able to devote to this the requisite funds. This branch of the industry is, however, being developed gradually. Before the division of India, the undivided Province of Bengal produced about 2,400,000,000 pounds of fish annually. As most of the rich fishing grounds and fish-culturing centers are included in the part

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that is now Pakistan, it is reasonable to suppose that more than two-thirds of that production of fish is still available in East Bengal. This figure excludes the enormous quantity of fish that is being harvested for individual domestic consumption by the so-called subsistence fishermen!

INLAND FISHERIES

The inland fisheries of East Bengal might be divided into: (1) riverine fisheries, (2) pond fisheries, and (3) estuarine fisheries.

1. RIVERINE FISHERIES

The major rivers of East Bengal--and a large majority of the smaller ones, too--teem with fish of numerous species. The predominant carp are the catla, Catla catla; the mrigal, Cirrhina mrigala; and the rohu, Labeo rohita. There are at least three species of catfish which are highly prized. The Indian shad, Hilsa ilisha, an anadromous fish that ascends rivers to spawn during the monsoon months, is fished for extensively during its sojourn in the rivers. The waters are virtually combed with all types of gear for this shad. Though a trifle bony, this fish has excellent flavor and delicate meat when it is in roe. It is considered the queen of all fish and commands a universal appeal in East Bengal.

The ownership of the riverine fisheries rests with the Government. The rivers are arbitrarily sectioned off, and the fishing rights therein are sold at public auction--annually, or once in 3 or 5 years, as the case may be--to the highest bidder. The lessee exploits the fishery by subletting to groups or individual fishermen.

The gear used ranges from simple traps and rod and line to very expensive and complicated nets. The boats are of diverse construction and size. Power propulsion is not resorted to save in fish-transporting craft.

To prevent indiscriminate slaughter of young fish by the use of small mesh nets, the Government has promulgated legislation banning the use of certain objectionable types of nets. Before the enactment of this legislation, millions of the young-of-the-year fish used to be killed. This practice, if it had been allowed to continue, would have caused a marked decline in the fisheries. The signs of such a decline were, as a matter of fact, already manifesting themselves. The destruction of brood fish--which is an easy matter when they congregate in dense shoals in confined areas--is also illegal in Pakistan during certain specified months. In some localities, permanent fish sanctuaries are declared, protecting both young and brood fish. The breeding grounds of the major Indian carp and of other fish of commercial value have been located in almost every important river. These are generally closed to fishing during the monsoon months.

In most cases the fishing grounds are very far from the consuming centers and, because of the absence of highways and other means of communication, are inaccessible from cities. In such situations the fish is preserved by sun-drying. This type of sun-dried fish is in great demand in Pakistan.

As is seen from the foregoing account, there is only conservation and exploitation of the river fisheries: there is no culture operation.

2. POND FISHERIES

The pond fisheries deal chiefly with the Indian carp, though attempts to culture catfish, Pangasius sp., are made in some ponds. The pond fisheries are very important in East Bengal as a source of fish for areas which are far inland, away from either the sea or other inland fishing areas. Also, people depend on ponds for their fish supply during times of heavy monsoon, when fishing elsewhere is not possible. The general types of ponds are: (A) culture ponds and (B) trapping ponds.

A. Culture Ponds

These are ponds in which aquiculture is carried on in the same way as agriculture. These ponds may range in size from a fraction of an acre to one or two hundred acres. The majority of these ponds are artificial impounds made primarily to provide water for agriculture and domestic use. The Province is virtually studded with ponds of this type. As East Bengal is a low, flat country in general, the construction of houses requires that the ground be raised by digging earth from the neighborhood. This excavation creates a pond next door to a homestead. The pond becomes a multiple-purpose project, as it were, providing water for domestic use of the owner, serving as a place for washing, for culturing fish, etc. The owner of the pond either cultures fish himself or rents the pond to others.

The fish seed (carp) are bought from fry dealers and reared in small nurseries till the fish are large enough for stocking the pond. The pond usually is not fertilized,

but the washing of clothes and the entry of other domestic refuse from the surrounding homesteads keep the pond rich in the microscopic food of fish.

Of the three major carp cultivated, the catla is about the fastest growing. This attains a weight of about 2 to 2½ pounds in 1 year. The other two species get to about ½ pound in 1 year. Between 1,500 and 2,000 fingerlings are stocked per acre, and three-fourths of these will be catla. Roughly, 700 to 800 pounds of fish is produced per acre per year with no artificial feeding or fertilization of ponds.

Carp Fry Trade

Because of the systematic culture operations in ponds and the concomitant demand for fry, the carp-fry trade is an organized one. The Indian carp spawn in small tributaries of the rivers and inundated ricefields during the monsoon months. The spawn drifts downstream. The spawn-collectors, who know from experience where and when the carp spawn, set out to collect the spawn in small nets, which are generally conical bags made from mosquito netting. These nets are fixed along the river bank, the mouths facing the current. The nets are emptied periodically of all spawn collected. The spawn is then transferred to shallow nursery tanks, wherein the eggs hatch within a day or two. The sale begins at this stage. The spawn is sold on a volume basis to fry vendors, who carry it from door to door in small earthen pots slung on a pole across the shoulders. As the fry grow larger, the price also increases. About 8 to 10 ounces of very small hatchlings 3 to 4 days old will cost, on the collecting spot, perhaps 15 to 20 dollars. Fry about 1 inch in size cost 3 to 5 dollars per thousand.

The ponds are not drained for catching fish. Seining is the common method. The ponds are stocked and harvested almost annually. A certain amount of rod-and-line fishing is also done, but here greater emphasis is laid on catching fish for food rather than on sport. Sport is a byproduct.

The pond owners are, as a rule, faced with the problem of rank vegetation, both rooted and floating, in their ponds. Weeds, as is well known, interfere with both culture and capture operations. These weeds are cleared periodically by manual labor. This procedure does not become an uneconomical proposition so long as labor is cheap. Control of weeds by fertilization with inorganic fertilizers is unknown, for there is no organized production of such fertilizers in the country yet. In new ponds and in others that require fertilization, organic fertilizers like farmyard manure and compost are used. Also, the ponds cannot be treated with poisonous chemicals like sodium arsenite to control weeds, because the water is used very often for domestic purposes in addition to fish culture. In some ponds even the use of organic fertilizers in any large measure is objectionable for the same reason.

B. Trapping Ponds

Ricefields

Water stays in a ricefield for more than 3 months in a year. In some areas rice is grown two to three times a year. Fish of all descriptions find their entry into these ricefields in the egg or fry stage during the monsoon months. A large number of adult fish also migrate into paddyfields to feed and breed. These are all trapped in the ponds when the water recedes. These fish (mostly Anabas sp., Ophiocephalus spp., catfish, prawns, and shrimps) are caught before the ricefield dries up completely; so the rice farmer gets two crops from his field--one of rice and the other of fish.

In some ricefields, the fry of major carp are stocked and allowed to grow until the rice harvest. The carp find plenty of food in the ricefields and grow fast. As they eat insects, their grubs, and other organisms which probably are harmful to the rice plant, the quality of the rice crop is improved appreciably. Generally, fingerlings about 3 to 4 inches in size are stocked, and they are about ½ pound apiece in 3 to 4 months. When the field is ready for harvest, the water is drained into trenches that have been dug around the field especially to hold the fish for a longer time. This type of fish culture is called paddy-cum-fish culture and is very popular in Pakistan.

Bherries

Bherries is a local name for a type of trapping pond constructed in low areas adjoining rivers and creeks wherein the water ebbs and flows because of tides in the sea. A low area, if properly embanked, becomes a good pond. Tidal water is made to enter through canals guarded by sluice gates. Such low areas are generally situated in regions where the water is brackish in the rivers. In East Bengal brackish water appears in rivers even as much as 40 to 50 miles from the sea. This has rendered vast acreages of good land unfit

for agriculture because of the high salinity. In such locations the bherries are usually constructed. The eggs and fry of brackish-water fish (Lates sp., Polynemus sp., Mugil spp., shrimps, etc.) get into these bherries and cannot escape because of the sluices in the canals. The fish are harvested periodically. During most of the year the bherries contain fresh water because of the heavy monsoon. It has been found that these brackish-water fish grow faster in fresh water.

There are also paddy-cum-fish bherries. Here the flat area, when it is protected from the entry of unregulated brackish water and after it has been washed time and again by fresh water, is used also for growing rice. The fish are found, in such instances, in canals ramifying the ricefield. During the flood months, the water from the canals enters ricefields--and along with it, the fish. This affords the fish a larger grazing area. As the water recedes, the fish get back into the canals, from which they are harvested by means of traps, hook and line, seines, etc.

The bherries are usually very extensive--quite a few hundred acres. The production of fish from these areas is almost astronomical. In some bherries, attempts are made to keep the fish of different species segregated in distinct canals instead of having a mixed culture of all species. There is no available information as to which of these methods is more desirable.

Bheels

Bheels are vast low areas adjoining rivers. On account of their poor, eroded soil, they are not fit for rice cultivation. Such areas are numerous in Pakistan, especially in the eastern section. They get inundated during the monsoon months, when connection is established between the main river system and the various bheels. The river fish enter these waters mostly for feeding and breeding. When water recedes during the winter, these fish and their young are trapped in deeper regions. In most bheels, by subsequent fertilization and improvement, certain areas are rendered fit for rice cultivation, when a state of paddy-cum-fish culture exists. The bheels are fished once in 2, 3, or 5 years. Many of these bheels are Government property. The right to fish is leased at public auction. The lessee is enjoined to keep the bheel in good condition by making such improvements as are recommended by fishery officials from time to time. The Government's revenue from the sale of fishing rights in bheels is enormous. A bheel of about 500 acres might fetch as much as $15,000. The bheels are fished only once during the lease period. The entire area is combed for fish with special types of seines (flexible bamboo screens). A group of bheels is called a haor. In a haor, two or three bheels are designated as permanent sanctuaries. Here the fish, because they are not disturbed, breed freely. These fish will replenish the stock in the neighboring bheels during the monsoon period, when the haor is a vast continuous sheet of water.

As most of these bheels are located in out-of-the-way places that are quite inaccessible from cities, the fish cannot be marketed fresh. Most of the catch, therefore, is preserved by sun-drying. A very small percentage of the catch finds its way to the consuming centers in a fresh condition. The sun-dried fish sometimes fetch a better price than the fresh fish.

3. ESTUARINE FISHERIES

The network of rivers and creeks in the deltaic region of East Bengal, called the Sunderbans, is a mine of fish wealth, teeming with species of high quality. The principal ones are Hilsa ilisha, Mugil spp., Polynemus sp., Serranids, shrimps, etc. Very little of this fishery is being exploited at the present moment because of the inhospitable nature of the jungle fringing these waters. However, governmental plans are under way to create in this region conditions suitable for the exploitation of this rich natural resource.

MARINE FISHERIES

As stated elsewhere in this report, the Bay of Bengal is fished only in its littoral region. Deep-sea fishing is as yet in an experimental stage. Pakistan is keenly watching the results of trawling operations that the Government of Indian Union is carrying on at the present moment in this bay with the help of some Danish fishing experiments. The inshore fisheries of the Bay of Bengal include a multitude of species of fish, a phenomenon that appears typical of almost every tropical situation. Most of these fish are greatly esteemed by the fish eaters. The pomfret, Stromateus spp., is one such fish.

Fishing is done generally during the winter when the weather conditions in the bay are favorable. The craft are not mechanized; they are propelled by sail and oar. They are rugged sea-going vessels, constructed of teakwood, of different size and design. Seines and trawls are the usual type of gear employed. Gill nets, too, are used. The

catches are sun-dried in most places. Some quantity of fish is, however, shipped fresh. Areas around the various islands in the bay are fished most. The fishermen are migratory, following the fish and establishing temporary fishing camps on the islands during the fishing season. Sharks, too, are caught in appreciable numbers. Their meat is filleted and sun-dried. It finds favor with some poorer classes of people. The livers are saved for extraction of oil, which is rich in vitamin A. The Government laboratories refine and bottle the oil for use in the hospitals. These laboratories also produce fish glue, fish meal, semidried prawns, etc., on a commercial scale and carry out investigations on a wide variety of fishery subjects.

GOVERNMENT AND THE FISHING INDUSTRY

The Government, through the agency of the Department of Fisheries, handles the conservation of the various fisheries in the country. The program of amelioration of the socio-economic condition of the fishermen--the producers--is given the highest priority. Schools for fisherchildren are established in fishing villages. Fishermen's cooperative societies, which enable the fisherman to market his goods independently of the middleman, are set up wherever possible. This has meant a considerable improvement in the economic status of the fisherman. Consumer goods like kerosene oil, sail cloth, coal tar, hooks, and wood for boats, are supplied at subsidized prices to bona fide fishermen. In short, every effort is made by the Government to uplift the downtrodden fisherman, both socially and economically, and free him from the clutches of the unreasonable middleman.

Model fish farms, embodying the results of modern research in pond culture, are set up here and there to teach modern and more efficient techniques of fish culture to fish farmers. Quality fish seed is supplied at low cost to interested pond culturists. Owners of ponds lying in disuse for one reason or other are induced to improve the ponds and culture fish to remove the malaria hazard. When the owner is found incapable of accomplishing this, the pond is acquired by Government and developed departmentally. Such fish farms have always proved a very profitable proposition. In East Bengal, it has been realized more than ever before that fish culture is as profitable as agriculture, if not more so.

FRESH-WATER FISHERIES OF MEXICO

Since 1950, a commission created by the Navy Department of Mexico has been studying the possibilities of developing fish culture on a more scientific basis. A part of this development program has been the appointment of Jorge Carranza, with a Rockefeller Foundation scholarship, to graduate work at Alabama Polytechnic Institute.

Mr. Carranza reports that one of the problems encountered by any fisheries program in Mexico arises from the fact that fish food has been so scarce--and hence so expensive--that people generally have not become accustomed to eating it.

The over-all program includes the study of native fishes such as the pescado blanco and "charal" (Chirostoma), catfishes, and mojarras (Cichlasoma), which are to be used as food fishes in lakes and ponds; the application of fertilizer and the desirability of using it; and, in general, the application of modern fish-cultural techniques to the particular biogeographical conditions noted in Mexico.

As Mr. Carranza points out, fisheries for crayfish, tadpoles, and salamander larvae have long been a source of food and the culture of these forms may be more desirable than that of fish in some waters.

"Insect fisheries," writes Mr. Carranza, "are another source of food. In the remains of ancient Lake Texcoco (in which Mexico City was founded), great numbers of aquatic insects of the families Corixidae and Notonectidae lay their eggs by the million among submerged plants. During the breeding season, insect fishermen submerge mats made of cattails in the lake. Returning 2 or 3 weeks later, the fishermen take ashore mats that are covered with eggs. After the eggs have dried on white cloths in the sun for 3 or 4 hours, the mats are shaken and the detached eggs are collected in the cloths. The eggs are then sold and shipped to different markets to be sold as 'ahuahutli'--called 'Mexican caviar' by some people. Adult insects are fished with nets of small mesh and used as bird food."

METHODS AND TECHNIQUES USED IN TRAP-CROPPING LARGEMOUTH BLACK BASS FROM LAKE MILLS, WISCONSIN, HATCHERY PONDS

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Lake Mills, Wisconsin

AFTER A NUMBER OF EXPERIMENTS with various methods of harvesting fingerling largemouth black bass from the ponds of the U. S. Fish-cultural Station at Lake Mills, Wisconsin, it was decided to try cropping with traps, that is, to remove a portion of the crop at various times when the fish were more readily available through the use of traps.

In our experience with transferring fry from the spawning ponds to rearing ponds, we have usually found considerable loss when we compared the numbers of fry placed in a pond with the numbers of fingerlings removed. We believe that this loss was due to many causes but principally to the unavoidable handling of the delicate fry when they were transferred to containers and again when transferred to rearing ponds, where conditions may differ widely from those in the spawning pond.

Regardless of cause, we believe that our cropping method avoids these losses. We first locate and construct a flat resting place for our traps directly under the water supply pipe. Our ponds receive water by gravity flow through a network of 14-inch pipes from Rock Lake, which is about a quarter of a mile distant. Our ponds are stocked with 30 to 80 breeders per acre, the number of fish depending on the condition, weed development, and depth of pond. Cropping is started when the resulting fry reach a size of about 1¼ to 1½ inches.

The traps used measure 2 feet deep by any desirable length and width, such as 3 feet long by 2 feet wide for a small pond and correspondingly larger for a larger pond. We always keep the depth of the trap to 2 feet, however, as we find this size easier to use in removing fish and more convenient to handle and move about. The trap is made of 1- by 2-inch pine framework and has a V-shaped throat at one end. The slit in the opening, running perpendicular to the base of the trap, is about half an inch wide. The framework of the trap is covered with galvanized mosquito screen, which is conveniently applied with a stapler gun.

The trap is placed on the level spot (we use a flat-topped stone pile) beneath the water supply pipe, which is about 3 feet from shore; no leads are used in this method. The V-end of the trap faces the pond; the opposite, closed end faces the shore. The top of the trap extends about 2 inches above the water and is held down with a flat rock placed on each corner. Then the water is turned on. A small stream of roughly 40 gallons per minute can be tried, and adjustments can be made as desired.

The small fish will be attracted by the splash of the falling water, as well as by the current which results. Our water falls about 2 feet. The current flows right through the screen V: a glass V would deflect the current and therefore would not be suitable.

In ponds which are not piped for a running water supply, a portable pump may be substituted. The intake or suction hose should be placed as far from the trap as possible or, better still, in another pond if one is close.

As stated, the small fingerlings will be attracted and will enter the trap in surprising numbers. Because fresh water is entering the trap, a larger amount of fish can be held than is possible where the trap is near the pond outlet or along a pond edge. A wing or lead-in serves to no advantage in this system.

Our distribution is arranged so that fish are transferred from the traps directly into the distribution truck instead of being moved into a holding house first. Weighing and measuring are done at the trap. Less handling gives a better-quality fish. A great deal of difference will be noted by the driver when he arrives at the planting site, as the handling under the old system resulted in a fish of poorer condition. Fish should not remain in the traps more than 24 hours, for crowded conditions may cause the development of fungus.

Approximately half of the total population of the ponds can be removed in this manner. The balance is allowed to remain in the pond until later, when our other pond trapping is completed. We then start back at the first pond trapped and begin to draw it down. When the water level falls to about 2 feet in the kettle, we connect a 2-inch hose leading from the supply pipe to the collecting kettle. Approximately the same amount of water as was used to feed the trap is allowed to run into the kettle.

There are many advantages to this system. It keeps the water fresh: the pond water is cleaner and free of twigs, moss, and other vegetation. Fingerling fish seek the areas where the fresh, cooler water is splashing and are taken from the pond in a much better condition.

As anyone who has drawn a pond knows, there are always a number of straggling fish that remain in the shallow water and often are lost through becoming stranded. A stream of fresh water at the kettle will attract these stragglers into the kettle, just as a current of water attracted fish into the traps. Another advantage is derived from this use of the kettle. Sometimes when a pond is drawn it is desirable to leave the pond--and the fish--at about the 2-foot level. This condition may occur as quitting time approaches or bad weather interferes. In such situations we adjust the pond drain to function at the same rate as that of the water entering the pond. The pond can then be left until the next morning, by which time most of the remaining fingerlings will have been attracted into the kettle. They are kept in excellent condition by the stream of water feeding the pond. Even though the water is changing, the water level remains constant overnight. After the remaining fish are removed, the hose is used to wash any dirt from the concrete kettle.

This system has the added advantage of extending the distribution season over a longer period.

There are other adaptations of this system which can be used to suit local conditions and installations. We plan to stock our breeders at staggered intervals so that sufficient time will be allowed to trap several ponds before the fish in the next few ponds have reached trapping size. This will be done by various methods. We intend to use a colder water supply to retard the spawning urge and also to crowd other fish in tanks until time for stocking. By using these methods we were able to increase our bass production by more than 50 percent. With this experience it is believed that we can reasonably hope for another 50-percent increase this coming season.

UNOBSERVED MORTALITIES

An attempt to determine "hidden losses" was made at the Convict Creek Experiment Station (Bishop, California) of the U. S. Fish and Wildlife Service.

Freshly killed trout were released singly at intervals in a section of the stream and then followed downstream from the point of release. The greatest stream distance covered by a dead fish was 40 yards; the least, 6 yards. At these points the fish became lodged in rubble on the stream bottom or in slack-water debris near the stream bank. Unless the white belly was in view, it was impossible to find the dead fish. Detection was made easier by removing the fish slime with a concentrated salt solution and then staining the body with gentian violet and erythrosin.

Further experiments are in progress.

LAKE MAPPING IN WISCONSIN

Charles N. Lloyd
Wisconsin Conservation Department
Madison 2, Wisconsin

DURING THE ERA of the Civilian Conservation Corps, a program of lake mapping was initiated by the biology division of the Wisconsin Conservation Department and a large number of maps were made from soundings taken through the ice. W.P.A. help also was used in some areas. The results were that close to 1,300 lakes were mapped and drawings were made on 17- by 19-inch sheets. There were a few exceptions for very large lakes.

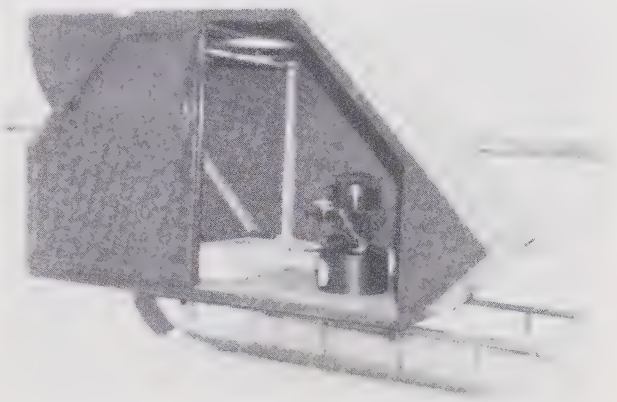
Because of the localization of the C.C.C. camps and the W.P.A. labor pools, the mapping was erratic and many areas were not touched at all. With the need for more information for fish management, the mapping program was renewed during 1952. A systematic program of mapping, county by county, is now in progress.

Experimentation with a fathometer has been carried on, and further consideration is being given the use of echo-sounding equipment for lake mapping. The major efforts now are being conducted with soundings through the ice.

Special equipment to facilitate the speed and accuracy of mapping by the method of sounding through the ice has been developed by the engineering division of the Wisconsin Conservation Department. The photographs show details of construction of this equipment, designed by Fred Jensen of the Department's engineering division. Procedure for use is outlined in the following paragraphs:

A medial control line is run with transit and tape, and a series of holes is drilled along this line at the interval selected for that particular lake--200 feet in small lakes or larger intervals, depending upon size and irregularity of bottom. At regular intervals, 1,000 to 2,000 feet, depending on visibility, control lines are run at right angles to the medial line, and holes are drilled at the same interval used along the medial line. These holes are flagged at the desired intervals for filling in on the lines parallel to the medial line.

If, for example, the soundings are to be at 400-foot intervals, flags are set at the 400-foot hole away from the medial line at each cross line. The cross, or perpendicular, lines are run out to shore on one side of the medial line as it is projected the length of the lake, and at least one parallel is flagged on the other side for the layout crew's return to the starting point. The layout crew has to retrace its steps on the perpendicular lines. After the control has been laid out, the fill-in work is begun. The distance between holes on fill-in work is measured with an odometer, which is checked and reset at each perpendicular. The odometer error is within 10 percent, which is closer than can be plotted. Most shore distances from the last sounding are obtained by pacing. The soundings, shoreline, and character of the shore are plotted on 4x4 graph paper, and any other items of importance are noted.

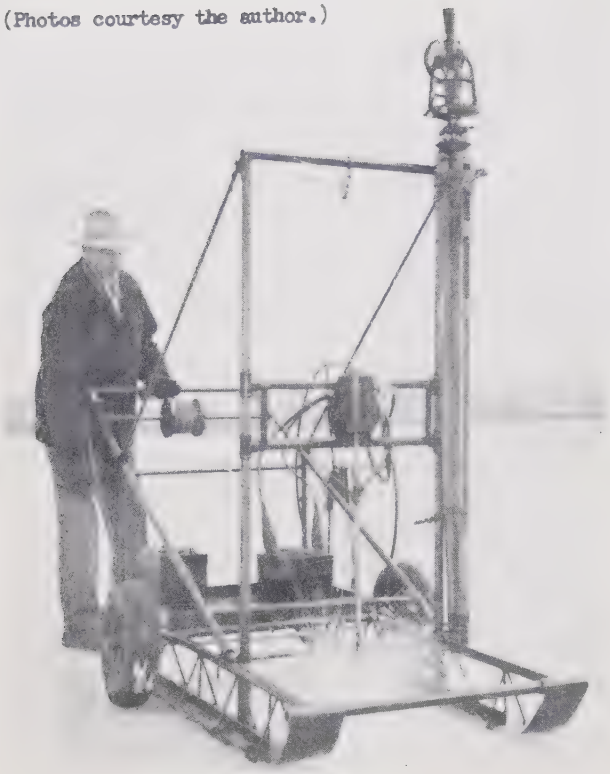


(Photo by Wisconsin Conservation Department, Madison, Wisconsin.)

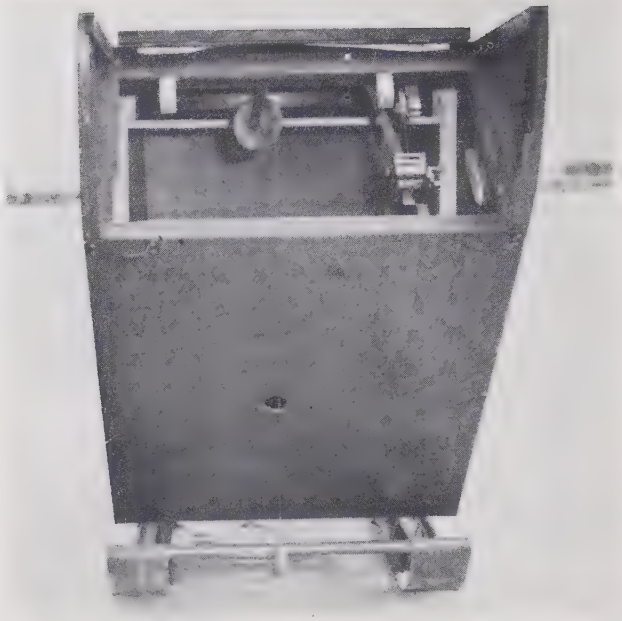
Sounding and recording sled.

Two different types of sounding units are used. The layout unit requires two steel sleds. The drill sled has a 2-inch auger run directly from a car's starting motor mounted on a frame similar in operation to a drill press. The sounding and recording sled has

(Photos courtesy the author.)



Drill sled in use. Operator's right hand is lowering drill; his left hand is on push button which operates solenoid starter switch. Note motor mounting and solenoid.



Rear view of sounding sled with glass tipped completely out of the way and drawing board removed. The sounding line may be traced from the reel to the recording sheave, around horizontal-mounted bicycle wheel, back to the rear of the sled, and down over another sheave. The wire line coming from the sled housing has a cable leader, swivel, and snap attached to the sounding lead.

built on it an enclosure large enough for two men to sit in the doorway, out of the weather. On the back is a drawing board on which 17x22 graph paper is mounted. Just below this board and to the right is the sounding reel for the Monel wire line and recording sheave. This is covered with a hinged glass for protection. A gasoline stove provided to heat the enclosure keeps the sounding equipment from freezing and the drawing board warm. A 12-foot sounding pole is carried for shallow depths.

The fill-in unit is the same as the layout unit, except that it is all on one sled. All equipment used in the drilling and sounding work is operated from the rear of the sled.

All sleds are identical and equipped for the mounting of wheels to facilitate movement over bare ground to the ice. The wheels are often left on, as they work very well on bare ice. Snow conditions on the ice have created the greatest problems. A tractor to pull the sleds is being developed and has proved satisfactory on a trial run.

If the lake has more or less uniform bottom topography, the readings are uniformly placed. If, however, it shows marked irregularities, the soundings are adjusted accordingly, much as one maps topography on the ground, taking frequent shots where there are strong variations and few where there are gentle slopes.

The lakes are carefully tied to land survey corners and are contoured on the field sheet. The shore information as to roads, dwellings, etc., is supplied from aerial photographs.

The lake mapping is an integral part of fish management, as it is of basic consideration in preparing an accurate physical inventory of the public waters of the State. All available information is needed for each lake, and the mapping provides many data. The lakes can be classified as small shallow, large shallow, small deep, large deep, etc. The shoal areas can be measured. Accurate hydrographic maps are essential in any well-planned program of applied fish-management practices.

Because of the essential character of this activity in a program of restoration and management of the sport fishery, lake mapping qualifies for the expenditure of funds under the Dingell-Johnson Federal Aid appropriation. The lake mapping in Wisconsin is presently carried on under an approved D-J project.

SHOULD WE STOCK BROWN TROUT ?

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PRIOR TO THE TURN OF THE CENTURY there was a veritable rash of fish transplantations throughout the world. Everyone seemed eager to have as many different exotic species of fish in his locality as possible, and fish-culturists did a thriving business to supply the demand. Brown trout were among many European species that were widely distributed at that time, and both strains of the brown trout--the Loch Leven trout, Salmo trutta levenensis Walker, from Scotland, and the von Behr or German brown trout, Salmo trutta fario Linnaeus, from Germany--were introduced into this country. In the hands of fish-culturists and under wild conditions as well, these two groups of trout crossbred to such an extent that no clear strains of either of the parent stocks now remain. However, it was early recognized that these stocks were not distinct species, and the fish we have today may be properly called brown trout, Salmo trutta Linnaeus.

Angling enthusiasts rather quickly found themselves arguing the merits of this foreigner, and--as in all such controversies--the contenders were equally divided. They remain so today. However, in more recent years the debate has assumed regional proportions as well: in the West a general feeling of dislike is expressed, whereas in the East there are some who seem to prefer brown trout above all other species. Some of the points at issue in this controversy are not without foundation in fact.

A positive credit for these trout is based upon the fact that they are well adapted to warm-water lakes and to warm, slow-flowing streams that are not particularly favored by native species. Another, but certainly more dubious, credit is derived from the fact that brown trout seem to maintain themselves more efficiently in the face of heavy angling pressure than most other species of trout simply because the brown trout are more difficult to catch. This is especially true as they increase in size and age. It is a matter of common knowledge that large brown trout are a definite challenge to that elite group of anglers who are classed as "experts."

On the debit side, it can now be said with certainty that brown trout are also comparatively well adapted to cold-water lakes and to cold, rapidly flowing streams where these fish are in absolute competition with native species. In some of these situations, brown trout have actually displaced the native stocks; and because brown trout are difficult to catch, fishing in these waters has often retrogressed from excellent to mediocre or poor. Efforts to improve angling in these situations by means of repeated introductions of native stocks have usually terminated in failure. To be sure, the brown trout has failed in some cold-water habitats, but these are usually circumstances in which native stocks exist only with difficulty. Also on the debit side, it has been demonstrated repeatedly that brown trout become more and more piscivorous as they advance in size and age. This is perhaps equally true of all other species of trout; but because they are less wary, comparatively few of them reach the "size and age of cannibalism" that is attained by many brown trout.

A point that seems to have been overlooked to a certain extent is the history of brown trout culture and stocking, particularly in the West. As stated, there was an initial impetus in fish culture to propagate and distribute these fish with enthusiasm and abandon. Few indeed were the accessible waters of the time that did not receive an initial charge of these fish. This flurry gradually subsided as fish culture matured and interest was directed toward the propagation and distribution of native species of trout. Thus, during the last 25 years, the artificial propagation of brown trout has been abandoned in many hatcheries and throughout some States. What, then, has been the fate of brown trout in the numerous waters in which these fish were stocked and without benefit of artificial

stocking during this period? In some such waters the brown trout have failed, but in most others these fish have flourished even in the face of heavy fishing pressure, and in many of these waters the brown trout dominate the environment despite repeated introductions of native species. Some examples of this are the Upper Deschutes River in central Oregon, the Owens River in eastern California, and certain of their tributary lakes and streams.

In consideration of the foregoing generalizations, some facts obtained by the U. S. Fish and Wildlife Service at the Convict Creek Experiment Station, Bishop, California, during the past 3 years should be of interest. The results of 2 year-long experiments conducted to compare survival and growth of stream-resident brown trout with hatchery-reared, catchable-size rainbow trout have clearly demonstrated the superiority of the former. In both years, natural mortality was consistently lower for brown trout and they exhibited normal condition and growth patterns in contrast to poor growth and drastic decline in condition for the rainbow trout. Although additional trials are necessary to obtain conclusive results on these experiments, it is nevertheless evident that brown trout are particularly well adapted to high (7,200 feet above sea level), cold, rapidly flowing streams such as Convict Creek. It is of importance also to note that brown trout have not been stocked in Convict Creek for at least 15 years, and that the stream is subjected to very heavy fishing pressure throughout the 6-month angling season. Yet these trout are dominant in the stream despite periodic introductions of hatchery-reared rainbow trout during the fishing season. True, many of the latter are caught by fishermen who are unable to catch the shrewd browns, and thus the brown trout lead a sheltered existence in competition with the more easily caught rainbows.

Brown trout are also resident and dominant over rainbow trout in Convict Lake, the source of Convict Creek. Similar to the creek, this lake has not been stocked with brown trout for many years and, on the basis of recent studies, stocking of this species should never again be necessary. In the fall of 1950, experimental gill-net sets were made to obtain specimens of rainbow and brown trout for age, growth, and feeding-habit studies. The results were amazing as well as revealing. The total catch was 106 fish, consisting of 87 brown trout and 19 rainbow trout. Of the brown trout, 21 (24 percent) were large fish with a weight range of 10 to 15 pounds and all fish were in advanced stages of ripeness. To determine the magnitude and duration of the spawning run from the lake, traps were installed and operated in the inlet stream in 1951 and 1952, but not a single large individual was captured. Also, extensive inquiry revealed that fewer than 6 of these large trout were caught by anglers during an average fishing season. Stomach examinations of individuals gill-netted in 1950 indicated that the large fish were subsisting on a diet including 40 percent fish, and that in the third year of life there began a shift in feeding habits from strictly aquatic invertebrate forms to partial diets of fish. This was also apparent from scale examinations that demonstrated accelerated growth beginning in the third year. Since these large fish are not taken by anglers, and since neither trapping nor observations in the outlet stream or on lake shoals provided evidence to indicate that the fish spawn, they are nothing more nor less than a burden on the biological economy of the lake. Imagine the vast numbers of small trout that must be consumed by these monsters in a year to maintain themselves--and for no worthwhile purpose other than to stimulate the ability of a few anglers.

The total spawning run of brown trout that entered the inlet stream to the lake was captured in 1952 and consisted of 1,165 individuals: 754 females and 411 males. On the basis of sample ovarian counts of 14 females that were representative of the run, the potential egg yield was estimated at approximately 800,000. To handle this number of eggs and to rear the resultant fry to fingerling size would require a small hatchery. Remember that this is for one 168-acre lake. Small wonder that rainbow trout in Convict Lake find the competition exceedingly difficult.

What, then, is the answer to the question, "Should we stock brown trout?" Obviously, a single answer is not the solution, but at least mature thought and consideration should be given the demands of anglers for the propagation and stocking of this species of trout. If nothing else has been learned from more than half a century of experience, it should be this: the distribution of exotic species of trout should be attended with great care and rigidly controlled to prevent danger to and displacement of native stocks that have demonstrated their value to recreational fisheries.

Chinese fish-culturists are reported to have used hens' eggs as incubators.

USE OF PELLETS AS TROUT FOOD

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THOUGH THE USE OF PELLETS as a food for hatchery trout apparently offers a number of advantages, additional work under hatchery conditions is necessary in order to determine the actual efficiency of this method of feeding. The amount of food to be handled, the cost of the food, the rate of conversion of the food into fish flesh, the food cost per pound of fish, and the percentage of gain are among the factors to be considered in appraising the value of the pellets. An experiment with pellets was therefore begun at the Spearfish (South Dakota) Fish-Cultural Station of the U. S. Fish and Wildlife Service on September 19, 1952, and continued until March 1, 1953.

The pellets used in the experimental work at the Spearfish Station were composed of the following ingredients:

	Percent
Dried skim milk, spray process	11
Whitefish meal, 60% protein	16
Wheat flour middlings	24
Cottonseed meal, 41% or 43% protein	24
Salt iodized, fine grade	4
Distiller's dried solubles, finely ground	11
Dried brewer's yeast, steam-dried	10
	100

The pellets were made 1/8 inch in diameter and about 3/16 inch long.

While the pellets were being prepared, an equal amount of dry mixed feed in meal form was also prepared from the same ingredients. The purpose of this was to insure that the rations given to the control group of fish would have the same composition as the pellets.

The fish used in this experiment were brown trout which averaged 13.4 to the pound at the beginning of the work.

Six tanks in the hatchery building had been reserved for the experiment. The water supplies for these tanks were regulated so as to be as nearly equal as possible, and 50 pounds of the brown trout (670 fish) were placed in each tank. The tanks were then numbered in order, 1 to 6. When the tanks had been numbered, the assignment of each to the different lots was made by drawing two slips of paper at a time from six slips that had been numbered 1 to 6. The first two tanks so indicated were assigned to lot A, the second two tanks were assigned to lot B, and the remaining pair to lot C.

The fish held in tanks 1 and 5, designated as lot A, were used as the control group. These trout were placed on a diet of the station's regular mixed feed, which consisted of 12.5 percent beef livers, 37.5 percent pork melts, and 50 percent dry mix. This dry feed was the special mix that had been prepared at the same time the pellets were made up. The feeding level selected for lot A was that recommended by Deuel, Haskell, and Tunison (1942) in the Cortland feeding charts. Thus the level used for the control group of fish at the beginning of the experiment was 2.6 percent of the body weight per day.

The fish held in tanks 2 and 3, designated as lot B, were fed the pellets at the level recommended by a commercial manufacturer of pellets for trout feeding. At the start of the experiment, therefore, the level of feeding in these tanks was 1.7 percent of the body weight per day. For six consecutive days the fish in lot B were fed the pellets; on the seventh day these fish were fed, instead, a straight meat diet at the Cortland level. This meat diet was composed of 74 percent pork melts, 24 percent beef livers, and 2 percent salt.

The fish held in tanks 4 and 6, designated as lot C, were given the same mixed feed as lot A but at the same level as lot B (1.7 percent of body weight). This diet was fed for six consecutive days; on the seventh day the mixed feed was replaced by straight meat fed at the Cortland level.

The results of this experiment are shown in the accompanying table.

RESULTS OF PELLET FEEDING EXPERIMENT AT SPEARFISH, SOUTH DAKOTA
September 19, 1952, to March 1, 1953

Period	Pounds of feed	Cost	Conversion	Food cost per pound of fish	Percent of gain	Number of fish per pound at end of experiment
LOT A (Regular mixed feed diet at Cortland level)						
September (11 days)	31.5	$0.0970	2.50	$0.240	35	
October	85.0	.0970	2.40	.230	28	
November	90.0	.0970	2.60	.252	24	
December	116.0	.0970	2.40	.233	27	
January	146.0	.0970	2.00	.194	32	
February	157.6	.1000	2.58	.258	22	
Summary	626.1	$0.0995	2.40	$0.234	261	3.63
LOT B (Pellets at commercial manufacturer's recommended level for 6 days and straight meat at Cortland level on 7th day)						
September (11 days)	20.25	$0.0890	2.53	$0.225	22	
October	63.10	.0830	2.02	.167	29	
November	63.00	.0830	2.01	.167	23	
December	78.60	.0860	2.23	.191	21	
January	92.00	.0834	1.56	.130	29	
February	94.50	.0897	2.30	.206	17	
Summary	411.40	$0.0863	2.00	$0.172	206	4.25
LOT C (Mixed feed diet at same level as Lot B for 6 days and straight meat at Cortland level on 7th day)						
September (11 days)	20.25	$0.102	3.30	$0.330	17.0	
October	63.20	.100	2.90	.290	20.0	
November	62.00	.106	2.91	.308	17.0	
December	71.20	.113	2.66	.301	21.0	
January	80.20	.100	2.10	.210	22.0	
February	80.80	.102	3.68	.375	10.3	
Summary	377.60	$0.104	2.80	$0.290	136.0	5.50

In view of the decided saving in labor and the potential saving in hatchery food costs, it is believed that further experimentation with pellets should be directed toward determining the most effective level of feeding, the necessity for feeding a supplementary ration of fresh meat, and the most efficient formula for pelleting.

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FACTORS IN "RED TIDE" OUTBREAK OF 1952

While processing data collected during the November 1952 outbreak of "red tide" off the coast of Florida, the Gulf Fishery Investigations of the U. S. Fish and Wildlife Service found good evidence that effluents of the Caloosahatchee River are important agents in such blooms. It has been noted that activity of this type is probably due to organic content as well as to physical attributes. Experimental work in tanks has indicated that high light intensity, vitamin B_{12}, and sulfides are some of the requirements for mass growth of dinoflagellates as well as other organisms.

Chemical analyses that have been made by the Geochemistry and Petrology Branch, U. S. Geological Survey, show that significant quantities of titanium and zirconium were present in the "red tide" bloom water--and not in other waters such as Lake Okeechobee, the surface of Sigsbee Deep, and the tidal lagoon at Galveston.

OCCURRENCE OF HIGH MORTALITY AMONG CHINOOK SALMON FRY AFTER THE RECHARGE OF A CHARCOAL FILTER

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FOR ABOUT TWENTY YEARS the city water used in the hatcheries of the School of Fisheries at the University of Washington has been passed through beds of activated charcoal, principally for the purpose of removing small amounts of free chlorine. These filters have varied in size and shape but have been essentially as described by Sharp (1951).

There had been no incidence of mortality associated with the use of the filters until December 29, 1952, when, after the recharging of the system with gravel and activated charcoal, a high mortality occurred in experimental lots of chinook salmon fry, Oncorhynchus tshawytscha. Mortalities then ranged from 5 to 100 percent in lots supplied with the filtered water.

The distressed and dying fish from these lots swam in a vertical or near-vertical position at the surface and appeared to be gasping for air. The caudal region had a scalded appearance, and behind the dorsal fin there were patches noticeably lighter in color than normal. After the period of erratic swimming, the fish settled to the bottom of the tank or trough and many appeared to be in rigor except that the opercles continued to function weakly. In many fish the cornea of the eye became opaque, and in some fish the eyeballs were greatly distended. In a few fish the eyeballs were ruptured. Of the fish that survived, many were blind in either one or both eyes. The dead fish were thickly coated with mucus.

Although the fish were in distress within a few minutes after the water from the recharged filter entered the tanks and troughs, the process of dying was gradual and it was difficult to distinguish immediately between the dead and the near dead. For this reason the dead fish were not picked off until the following day. The pick-offs for the first 24 hours are listed in the column "Mortalities, Dec. 29 and Dec. 30" in table 1. After January 1, mortalities were no greater than for the period immediately before December 29. The complete list of mortalities and other pertinent information about the affected lots of chinook fry are given in the table.

All the fish in these lots were the progeny of one pair, spawned on October 13, 1952. The fry in the yolk-sac stage had grown to

TABLE 1.--Water temperatures and age, stage of development, number, and mortalities of chinook fry in lots affected by recharging of charcoal filters on December 29, 1952

Lot No.	Temperature, ° F.	Age (days after hatching)	Stage of development	Number in lot Dec. 28	Percentage mortality Oct. 13 to Dec. 28	Mortalities, Dec. 29 to Jan. 1				
						Dec. 29 and Dec. 30	Dec. 31	Jan. 1	Total	Percent
1	45, constant	4	yolk sac	480	4.2	20	0	5	25	5
2	50, constant	26	yolk sac	481	4.7	137	21	1	159	33
3	55, constant	38	early feeding	198	60.8	176	0	1	177	89
5	57½, constant	42	early feeding	232	54.1	205	2	0	207	89
6	60, constant	45	early feeding	12	97.6	12	-	-	12	100
4	47, varies with season	44	early feeding	441	15.2	234	11	1	246	56
8	47, varies with season	44	early feeding	1,564	7.2	857	53	5	915	58
Total				3,408					1,741	51

a fork length of 1-5/16 inches, and the early-feeding fry to 1-1/2 inches. All except the control lots had been reared at one of various constant temperatures. The control lots, No. 4 and No. 8, were reared at the temperature of the water as received from the city main. The water temperature for these two lots was 62° F. on October 13, at the beginning of the experiment, and had gradually dropped to 47° F. on December 29.

From inspection of the table there appears to be a relationship between percentage of mortality from December 29 to January 1 and the interrelated factors of water temperature, stage of development, and percentage of mortality from October 13 to December 28. The significance of the column "Percentage mortality Oct. 13 to Dec. 28" is that in the lots which had an appreciable mortality the vigor of the remaining stock may have been low. However, the relationship of any one of these factors to mortality cannot be definitely established, as the cause of the mortality (which was later demonstrated to be a high OH^- ion concentration in the water, as indicated by pH) was not measured in the tank when the fish were in distress and some variation in pH may have existed between tanks. Nevertheless, it would seem reasonable to assume that the chinook in the yolk-sac stage were affected less than those in the early-feeding stage.

In attempting to discover the cause of the mortalities, the procedures used in cleaning and recharging the filter were reviewed. The filtering unit consists of two tanks which can be operated singly or in series. During normal operations the unit is operated in series, but during recharging operations only one tank is kept in use while the other is being cleaned and refilled. On December 29 the first tank was recharged and then washed for 90 minutes before being put back into use. This resulted in no distress to the fish. The second tank was recharged in identical manner but was washed for only 15 minutes before being put back into use. Ten minutes after the second tank was turned back into the line, fish were in distress and dying. Oxygen was plentiful, as the measured amount present was more than 90 percent of saturation.

The following experiment was then undertaken in an attempt to identify the causative factor. Ten chinook salmon fry were placed in 1-1/2 gallons of water in each of six glass jars. One jar contained some of the fine gravel used in the filter beds; a second contained some of the coarse filter gravel; a third contained a cloth bag with 145 grams of unused "new" charcoal, i.e., charcoal from the lot that was placed in the filters on December 29, 1952; a fourth contained a bag with 131 grams of unused "old" charcoal, i.e., charcoal from a lot that was used to recharge the filters on a previous occasion; and the fifth and sixth jars, regarded as controls, contained water only. In the jar containing the "new" lot of charcoal, the fish were visibly in distress within 25 minutes and all the fish died within 90 minutes. The pH of the water in this jar was 11+. During the 24 hours that this experiment was continued, there was no distress or mortality in the other jars--not even in the jar containing the "old" lot of charcoal, in which the pH reached 9.0.

A second experiment was undertaken to determine whether the lethal factor was either the high pH of the water, i.e., high concentration of OH^- ions, or some other toxic agent. In this experiment a cloth sack containing 375 grams of the "new" charcoal was placed in approximately 2 gallons of water and allowed to stand overnight. The next day one-half of the water was transferred to another jar and then neutralized with HCl to a pH of 7.4. The pH of the water in the original jar was 12.25. Fifteen chinook fry were then placed in each of the two jars. Seventeen minutes later all the fish in the jar having the water of a high pH had died. In the other jar there was no mortality or sign of distress during the 3 days of the experiment.

Conclusion

The results of the foregoing experiments show conclusively that the high pH of the water produced by recharging the filters with a "new" lot of activated charcoal caused mortalities among chinook salmon fry. The fact that mortalities were experienced on this occasion but not on previous occasions when the filters had been recharged, was the consequence of two circumstances: (1) the second recharged filter had not been backwashed with sufficient thoroughness to reduce the pH of the water to a tolerable level, and (2) the activated charcoal used in the filters on December 29, 1952, produced an unusually high pH in the water passing through the filters. It is suggested to users of activated charcoal filters that the pH of the filtered water be checked carefully after each recharging.

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THE ROGUE RIVER BOAT IN FISHERY WORK

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THE DEMANDS OF VARIOUS OPERATIONS in fishery work call for boats that can operate under unusual conditions. Much fishery and limnological work must be done in shallow water as well as in deep; collections must be made in uncharted river channels; power, as well as speed and maneuverability, is required for the handling of gear and for quick access to other collecting stations. Many types of boats have been used in fishery operations with varying degrees of success, but it is difficult to find, or even to design, a craft that is suitable for all purposes. The present discussion centers on the Rogue River boat, a design that has been little used by fishery workers but which has had spectacular success on at least one project. The boat appears to offer much promise as a fishery tool.

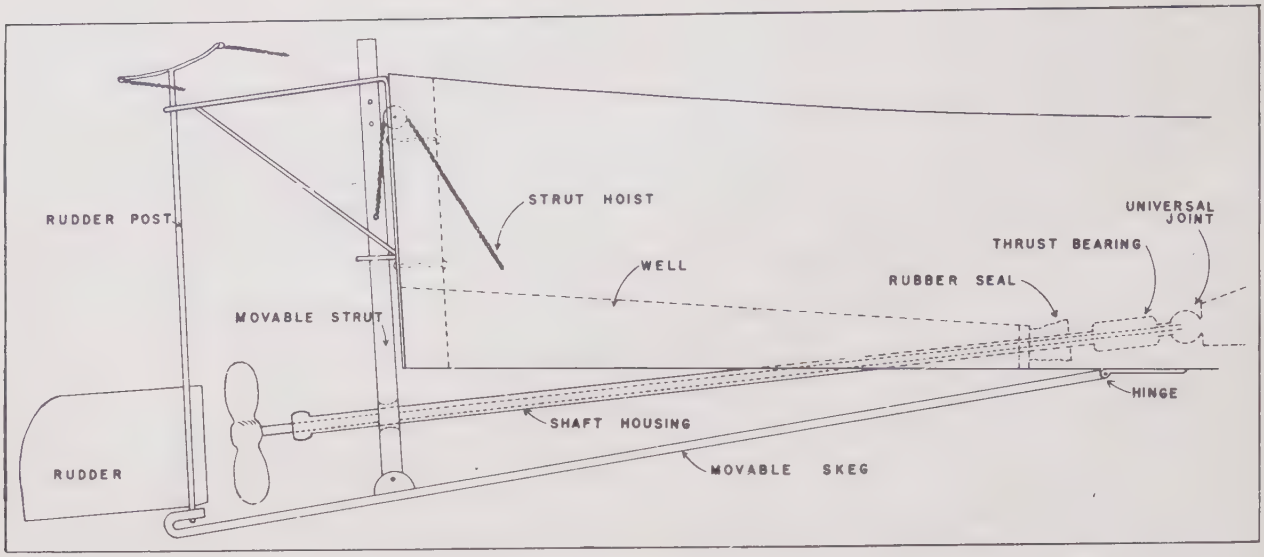
The Rogue River boat was developed in Oregon on the famous Rogue River, a salmon and trout stream of rapid, turbulent water that defies the piloting of most ordinary craft. A boat that can negotiate this river must possess power and speed for fighting the current, shallow draft for surmounting the rapids and working near the shores, and maneuverability for avoiding boulders and other obstacles. The Rogue River boat has evolved to meet all of these needs.

The feature that sets this design apart from others is a mechanism which enables the pilot to raise the propeller and rudder above their normal position in the water by merely depressing a lever or a foot chain. This hoisting mechanism diminishes the draft at the stern and enables the boat to pass easily over logs and rocks that would rip out the driving gear of the conventional fixed suspension. The longitudinal shape of the hull is further fitted for river work: although the design includes a transom, it is so narrow that the boat is practically a double-ender.

The U. S. Fish and Wildlife Service used a Rogue River boat in fishery operations on the Sacramento River, California, in 1949 and 1950. The work consisted mostly of pulling large-hooped fyke nets through the water for the collection of immature salmon. The tows were made in lanes, and horizontal and vertical control of the net was essential. Conventional boats were used with some success, but the Rogue River boat far surpassed others on several scores. The boat was very maneuverable in shallow water and against the current, and speedy access to other collecting areas was possible even through the dreaded China Chutes above Red Bluff, California. The boat had sufficient power combined with speed and was roomy enough to make an excellent work boat. Snags and rocks in the water were easily avoided.

The accompanying figure presents a semi-diagrammatic depiction of the lateral aspect of the stern of a Rogue River boat. The skeg is movable by virtue of its hinged forward end. The lower end of the movable strut pivots on the skeg, and the lower end of the rudder post is seated on the after end of the skeg. The shaft is attached forward to a universal joint and turns within a housing that extends aft beyond the strut. The shaft housing passes through a hole in the strut but is not fixed at that point. Brackets extend aft from the transom, and the strut moves within openings in the brackets. With this arrangement, when the strut is moved vertically, it carries the skeg, the rudder, and the shaft and attached propeller with it. The strut can be raised vertically by means of the strut hoist, a chain which can be controlled by the foot of the pilot or by other means. Steering is accomplished by means of a wheel and chains or lines attached to the rudder post. When the shaft and skeg are in the raised position, they are recessed in a well that lies along the longitudinal axis of the boat.

Power in Rogue River boats is provided by a marine gasoline engine or by an automobile engine with a modified cooling system. Automobile engines are in wider use on the



Features of a Rogue River boat.

Rogue River. The boat used by the U. S. Fish and Wildlife Service was powered with an automobile engine that developed 130 horsepower. Aft of the engine is the universal joint, from which the shaft leads into a thrust bearing and thence through a rubber seal connected to the forward end of the well.

The hull is usually constructed of marine plywood, 1/2 inch thick on the bottom and 3/8 inch thick on the sides.

Fishery operations in areas where weed patches make piloting difficult can make good use of Rogue River boats. The shallow draft, the speed, and the retractable propulsion gear enable the boat to glide over small weed beds easily. (Extensive weed growths could offer too much resistance for even this kind of boat.) Another common difficulty that this boat overcomes is beaching. The craft is run up onto the beach without danger to the propeller or rudder, since they can be raised.

If the pilot does not raise the gear with the strut hoist, it will raise itself as the boat comes into contact with sandbars, logs, or other obstructions. Although it is not good practice to depend on this action, it is a good safety feature.

CHANGES IN LENGTH MEASUREMENTS OF YELLOWSTONE TROUT

Since 1936, the U. S. Fish and Wildlife Service has recorded length measurements of black-spotted trout spawning in tributaries to Yellowstone Lake and in the lake fishery. From 1950 to 1952, the Service took measurements at frequent intervals.

Significant decreases in mean total length appeared in Pelican and Grouse Creeks from 1951 to 1952, and in Arnica Creek from 1950 to 1951 and from 1951 to 1952. Lengths in Chipmunk Creek fluctuated in late years. Streams tributary to the north end of the lake showed greater change than those entering the south.

In 1952, Grouse Creek fish averaged 14.8 inches, significantly longer than fish of all other streams. Yellowstone River spawners averaged 14.5 inches, also significantly different from all other streams. Differences between mean total lengths of fish of Pelican and Arnica Creeks were not significant.

Mean total lengths of fish brought into the Fishing Bridge area decreased yearly from 1950 to 1952. Fish taken in the West Thumb area decreased significantly from 1951 to 1952. Fish from all areas of the lake decreased in mean total length from 1951 to 1952.

In 1952, fish from Fishing Bridge area were longer (13.3 inches) than fish of other areas but significantly so only in relation to West Thumb fish (12.7 inches). Total length of fish from the combined fishery averaged 13.3 inches; from Yellowstone River outlet, 13.0.

DIVIDENDS FROM RESEARCH

POND RESEARCH IN ALABAMA

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In 1933 there were 700 millponds and fishponds in Alabama. Nothing, then, was known about how they should be stocked or managed. As a result, they were filled with weeds and produced pest and malarial mosquitoes and poor to indifferent fishing. In that year, the Agricultural Experiment Station of the Alabama Polytechnic Institute initiated a project on farm-pond management. As this was a research organization, the Director was familiar with the fact that good research could not be done without equipment for research--in this case, experimental ponds. Consequently, money was allocated for this purpose and the first experimental ponds were finished in 1934; the number has been expanded subsequently so that 143 experimental ponds are currently in use for the study of pond management at this station. As a result of this research, there were developed methods of stocking, weed control, fertilization, and pond management which gave pond owners the best fishing they had ever experienced. As their neighbors saw these results, they also began to build and manage their ponds to produce good fishing. Within the past 18 years, approximately 10,000 fishponds totaling 50,000 acres and valued at more than $25,000,000 were constructed in Alabama--a direct result of research. These Alabama ponds were built principally by farmers and sportsmen to produce fishing--and without benefit of government payments.

If the sport fish, bluegills and bass, were valued at only 50 cents per pond, the catch in 1 year from these ponds had a value 5 times as great as the total cost of all pond research at this station in the last 18 years.

This research benefited Alabama; as is usual with research, it also benefited surrounding States and foreign countries, which use in part the information developed and thus increase tremendously the returns on the money invested in pond research.

PERCH STUDIES IN GREEN BAY

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For years the commercial fishermen of southern Green Bay contended that the minimum legal length of 8 inches for yellow perch in that area should be reduced because (1) the perch population was stunted, incapable of reaching the size of 8 inches in any numbers, and (2) the larger perch tended to desert the southern part of the bay after spawning in May. To throw light on this perennially controversial problem, the Fish and Wildlife Service and the Wisconsin Conservation Department in 1948 initiated a cooperative program of study which included the marking of roughly 10,000 to 30,000 spawning-run perch annually, 1948-51, and the investigation of the age and size composition of fish taken in commercial nets.

In general, the views of the commercial fishermen were substantiated. Yellow perch grow much more slowly in southern Green Bay than in any other major fishing area of the Great Lakes. On the average, southern Green Bay perch require more than 5 years to reach the length of 8 inches, as contrasted to the attainment of 8½ inches in 3 years in Lake Erie and Saginaw Bay and in about 4 years in northern Green Bay. Length frequencies indicated that because of this slow growth many perch of southern Green Bay did not live long enough to reach legal size. Legal-sized fish were especially scarce in the spawning runs of 1950 (only 9.2 percent legal) and 1951 (11.8 percent legal). Even these few larger fish became scarcer after spawning, for the tagging experiments proved conclusively that the larger individuals tended to move away (northward) from the spawning grounds after the spawning season. Still another significant observation was that both male and female yellow perch were predominantly sexually mature at lengths of 7 inches and less, and hence that an 8-inch size limit was not needed for the protection of immature individuals.

Acting on the evidence that the 8-inch limit was preventing the efficient cropping of the production of yellow perch in southern Green Bay, the Wisconsin Conservation Commission reduced the minimum legal size to 7½ inches, effective at the start of the open season, May 20, 1952. Measurements of samples from commercial nets by Service biologists indicated that during the 1952 season fishermen were able to keep nearly 250 fish for every 100 they would have been able to keep under the former 8-inch limit. As a result, commercial operators enjoyed good fishing during a season that under the former size limit would have been a period of acute economic distress.

Samples of fish measured in 1952 yielded no evidence that the decrease in the size limit had changed the size composition of fish on the grounds. Plans call for careful observations to detect possible changes in later years in either size composition or growth rate of yellow perch in southern Green Bay.

This is an example of sensible regulations which resulted from research.

FISHERIES RESEARCH IN WESTERN CANADA

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It may be true that the public is not sufficiently aware of the extent to which the results of fisheries research have been applied with definite and substantial economic gain. From his experience in one part of western Canada, the writer would like to cite three rather different instances of success in this field.

In 1938-43 the writer directed an investigation of the saline lakes in the grassland area of Saskatchewan. Physical, chemical, and biological conditions were studied, and one of the conclusions was that some of the desirable fish of the area would tolerate salinities of 15,000 but rarely up to 20,000 ppm.[1] Much of the information from this study has been useful in fisheries management. For example, Redberry, a highly saline lake (15,000 ppm.) was chosen for planting of whitefish, Coregonus clupeaformis, and yellow walleye, Stizostedion vitreum.[2] It had previously contained only two sticklebacks and a minnow. Planted in 1940-44, both whitefish and walleye were successful. The lake began to produce commercially in 1945 and averaged about 60,000 pounds in the years which followed. The production is of fine quality and greatly appreciated in an area that is far removed from other fish supplies.

In 1944 we began an investigation of Great Slave Lake in order to estimate its fish-producing capacity.[3] While an enlightened administration held back the commercial interests wishing to exploit the lake, we were allowed to study the lake and recommend how it should be harvested. Of course, no one knows what might have happened without the planned and scientific approach. Nevertheless, we can take some satisfaction from the fact that the lake is now producing a steady 8 to 9 million pounds of top-grade trout and whitefish per year. Moreover, a continuing and rigorous analysis of the catch shows no evidence of the deterioration of the basic stock of fish in the lake.[4]

About 1948 it became obvious that limnological studies of the small ponds and reservoirs in Saskatchewan were necessary as a basis for stocking policy. About 125 were studied in some detail over a period of 4 years. The conclusion was that most of these waters were unsuited to fish production because of shallowness, weed growth, and especially winterkill.[5] The cost of these surveys may have equaled that of a small program of pond stocking in these 4 years. If, however, one contrasts the cost of the research with that of an extensive stocking program which, because of public and political opinion, might have had to be carried on for many years, it is evident that a little research made it possible to avoid a tremendous waste of public funds.

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MICHIGAN LAKE MAPS FOR FISHERMEN

Since 1930, the Michigan Department of Conservation's Institute for Fisheries Research has been mapping the State's 11,000 lakes. This work, now a Dingell-Johnson project, was undertaken for its value as a tool of fishery research and management. In the last 15 years, however, as copies have become available for 2,232 of these lakes, the public has gradually found other uses for the maps. Anglers are now referring to the charts to locate the better fishing areas, lake property owners are framing the charts and hanging them on their cottage walls for reference as well as for decoration, and many people who are in the market for cottage sites are studying the charts to learn whether a particular body of water meets their desires.

Demand for the maps has sharply increased as their availability has become better known. Sale of the maps has been primarily a public service, as the price of the prints is little more than the cost of reproduction.

A more recent public service has been the preparation of free folders for 5 of the more popular large lakes. One side of a folder has a colored map of a lake; the other side shows general information on lake inventories and a summary of historical, geological, physical, chemical, and biological data for the particular lake.

Clarence M. Taube of the Institute for Fisheries Research reports that though mapping is done during both winter and open-water seasons, in recent years most of the work has been done on the ice. Use of a sonic sounder on open water is being tried now, and this method is believed likely to supplant the winter program in future.